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ABSTRACT

In order to explore diverse philosophical, psychological, and pedagogical views on the concept of heuristic teaching and the question whether basic teaching skills can be "content free," a symposium on the subject of heuristic teaching was organized with resource papers being requested from scholars representing several disciplines and subject-matter areas. Papers in this volume discuss applications of heuristic teaching in mathematics, art, science, English, and social studies. Additional papers provide philosophical and psychological analyses of the topic and discussion of its implications for teacher education. (Author/RT)

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A SYMPOSIUM ON HEURISTIC TEACHING

Edited by Richard E. Snow

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Introductory Statement

The Center is concerned with the shortcomings of teaching in American schools: the ineffectiveness of many American teachers in promoting achievement of higher cognitive objectives, in engaging their students in the tasks of school learning, and, especially, in serving the needs of students from low-income areas. Of equal concern is the inadequacy of American schools as environments fostering the teachers' own motivations, skills, and professionalism.

The Center employs the resources of the behavioral sciences--theoretical and methodological--in seeking and applying knowledge basic to achievement of its objectives. Analysis of the Center's problem area has resulted in three programs: Heuristic Teaching, Teaching Students from Low-Income Areas, and the Environment for Teaching. Drawing primarily upon psychology and sociology, and also upon economics, political science, and anthropology, the Center has formulated integrated programs of research, development, demonstration, and dissemination in these three areas. In the Heuristic Teaching area, the strategy is to develop a model teacher training system integrating components that dependably enhance teaching skill. In the program on Teaching Students from Low-Income Areas, the strategy is to develop materials and procedures for engaging and motivating such students and their teachers. In the program on Environment for Teaching, the strategy is to develop patterns of school organization and teacher evaluation that will help teachers function more professionally, at higher levels of morale and commitment.

The symposium on heuristic teaching presented here was held under the auspices of the program on Heuristic Teaching. The papers represent the program's continuing effort to seek ideas and definitions that will contribute to the central theme of the research.

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PART I: INTRODUCTION

INTRODUCTION

Richard E. Snow
Program Director
Program on Heuristic Teaching

The Center's research and development program on teaching began, and has progressed, with the assumption that basic teaching skills could be conceived as "content free." While it was acknowledged that teachers did many things specifiable and understandable only in the contexts of particular disciplines, it was decided that Center work should concentrate on identifying a set of elemental teaching skills useful across all disciplines and developing training procedures for aiding acquisition of these skills by teachers. In recent years, as the program began focusing on the subset of the field called "Heuristic Teaching," the working assumption of content-free skills has been increasingly questioned. Some have even suggested that heuristic teaching skills could not be defined except in terms of specific subject matter.

The growing need to examine this issue in detail coincided with an established program goal aimed at continual elaboration and definition of the concept of heuristic teaching in general. It was therefore decided to organize a symposium on the topic and to invite resource papers from scholars representing several disciplines and subject-matter areas of particular relevance to the Center's work in teacher education. Various philosophical and psychological viewpoints were added for discussion purposes.

Following are excerpts from two Center Annual Reports. These passages represent an abstract of the heuristic teaching concept as described in the past and as provided to symposium participants for orientation. The result is the volume here presented.

The excerpt[1] on heuristic teaching from the Center's Second Annual Report follows:

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[1] Stanford Center for Research and Development in Teaching, Second Annual Report (April 1968). This passage was written by Frederick J. McDonald, then Coordinator of the program on Heuristic Teaching.

Although the idea that man must adapt to social and physical change is widely accepted, some of its consequences have not been recognized or fully accepted. If the ability to adapt to complex life situations is as critical as it appears to be, it is important that a substantial portion of educational effort should be devoted to developing individuals who are adaptive, flexible, and inventive. That our educational energies are not so devoted is abundantly clear. Although society is changing rapidly in many ways, the schools are changing very slowly.

The Inadequacy of Didactic Teaching

Teaching style is probably the most static aspect of schooling. Teachers teach today in much the same way as they have for generations. The basic style is didactic, with the teacher dispensing information to passive pupils. At regular intervals, the teacher examines the children upon how much of this information they have absorbed and retained. It is the teacher who asks questions, rarely the pupil. The structure of the answers is predetermined by the context in which the questions are formulated; only infrequently does a child's schooling permit him to discover problems. The answers are known; if they are not known by the teacher, then certainly they can be found in a book. Occasionally these stretches of information dispensing and receiving are broken by moments of creative activity. But, more frequently, the didactic method continues uninterrupted, accepted on the assumption that knowing "these things" is important.

It is not necessary to prolong this jeremiad on the current state of teaching. Over the years, great teachers have deplored the paucity of imagination, and the sterility of the methods used in most teaching, but even the fervor of the Progressive Education movement in the United States accomplished little.

The Computer and Audiovisual Revolutions

What reasons are there to believe that a change can now be wrought? The answer is that a new element has been added to the social forces impinging on the schools, namely, the computer and audiovisual revolutions. Teachers' didacticism has persisted because there was no substitute for it. Children needed to learn information; the teacher was the guide to and the dispenser of that information. Not even the widespread availability of books changed this system.

The computer and various audiovisual media make possible a better information dispensing system. In two decades or less, computers will be integral components of an electronically based educational system. These components and audiovisual systems will be used extensively as unit costs go down and comparative effectiveness is demonstrated; their educational validity is already well enough known to warrant our predictions.

Even if one were not sanguine about the development of media and computer-assisted instruction, he must recognize that the world has changed substantially because of the widespread availability of information. He has only to turn on a television set or pick up a magazine or newspaper to have available more information than his grandfather may have had in a year. He has a sense of immediacy, of closeness to events as they are transpiring. He need not imagine what people look like; he sees them on television and in pictures in magazines. Pictorial journalism, whatever the media used, has opened up to him a world of symbols, images, and colors.

In such a world, how does one know what is worth knowing? The richness available forces a choice of what to read, watch, and remember. Such choices require principles by which one can make the decisions that lead to selection.

The didactic teaching style helps very little in enabling one to develop such principles. The didactic method is but another aspect of the information flow. The very technology that facilitates communication tends to enhance and stimulate the didactic processes in schooling. A teacher can now turn on TV in the classroom, bringing into it a better dispenser of information than he is. The day is not distant when children will go to computer terminals for access to vast libraries.

The computer and electronic revolutions have had another consequence, probably more serious. They are the symbols of depersonalization. Only a relatively few sophisticated members of our society are aware of the extent to which the machines are controlled by men. The vast majority see the computer as an impersonal force capable of making decisions for and about them, and one over which they have relatively little control. Similarly, despite all the claims about the potential educational value of television, disparaging references to its programs and processes are frequent. In our society, the machine is often seen as a threat to one's sense of identity.

It would be simple-minded to claim that the didactic teaching style has rendered human beings helpless in the face of profound technological change. It would be equally wrong not to recognize that that style, now the dominant approach to the inculcation of knowledge, does not engender ways of coping with profound social changes now occurring.

Alienation of Youth and Didactic Teaching

Only the schools can provide a wide variety of approaches to learning. If the learner's reception of information is likely to be facilitated by technological developments, what are the likely consequences of this facilitation? Will we also facilitate the acquisition of passivity, indifference, and alientation? That these are not unlikely outcomes seems apparent when we consider the mood of the present generation of high school and college students. Large numbers of them are alienated from their world. Others are in active rebellion against a social system which they think regards them as statistics in manpower counts rather than as human beings. They charge that the educational system is forcing upon them a way of life whose values they cannot accept. They are demanding new forms of education which will help them develop as persons.

Although it has many causes, the alienation of large numbers of middle-class and minority-group youth attests to widespread dissatisfaction with American education. Many adults recognize the disparity between what the schools teach and the needs of youth, but it is the students who have pointed to the inadequacies of the way in which they have been taught. They attack the passivity of their role, the lack of involvement of their teachers in the teaching process, their exclusion from the decision-making processes which determine the nature of their education.

Vague as some of these problems seem, the prevailing mood is unquestionable to demand and provoke change in the nature of education. At present, the discontent is more apparent than the nature of the problem or the most effective way to solve it.

A decade ago, dissatisfaction with education took the form of criticizing what was called the "quality" of education. Quality was synonymous with traditional conceptions of academic achievement. The resolution of this dissatisfaction took the form of innovations in the curriculum, such as new mathematics and science programs, and greater emphasis on academic achievement. One consequence of these changes was an enhancement of the didactic mode of teaching. The good teacher became the teacher capable of increasing acquisition of subject content.

Disadvantaged Children and Didactic Teaching

This emphasis on academic achievement occurred about five years before another profound change in American society--the explosion of the effort of the Negro and other minority groups to find an equal place in our society. Nowhere is the inadequacy of the didactic mode of teaching more apparent than in the ghetto schools. Many have noted the irrelevance of the curricula of these schools; few have observed that their teaching styles reinforce those very characteristics which help to maintain the inferior status of the minority-group member.

The didactic mode requires much passivity of the student. It encourages an authoritarianism of the book, where the printed word becomes the standard of truth. Receptivity to it requires detachment and delay of personal gratification.

Again, it would be too simple to blame the problems of minority youths in the schools on the teaching style to which they are exposed. It must nonetheless be recognized that this teaching style contributes to the alienation of minority youth from schooling.

Heuristic Teaching: The Necessary Supplement

Heuristic teaching refers to styles of teaching which emphasize the development of self-initiated and self-directed pupil learning; which stress the pupil's discovering rather than absorbing knowledge; which place the student in the role of the inquirer; which aim at heightening the relevance of school to the pupil's life; which are concerned with the emotional and social development of the pupil as well as with his cognitive growth. Teaching in the heuristic mode represents no one style of teaching behavior or activity. It may be characterized as imbued with the spirit and mood of inquiry, critical skepticism, invention, imagination, and enthusiasm for learning. It treats students as persons who can produce knowledge and understanding. It is revealed in sets of beliefs about the way in which knowledge and understanding are integral to personal development and the meaning of existence. It may be the essence of the varied styles of great teachers who inspire students to seek understanding.

We will not attempt here to describe in detail all that is meant by heuristic teaching. . . . One way to understand more clearly what is implied in this concept is to look at heuristic teaching from the perspective of the teacher and then from the perspective of the student.

From the Teacher's Perspective

Heuristic teaching styles will take many forms. We here decide the characteristics of heuristic teaching as we now see them. The concept will change as we study this teaching style in practice. Also, whether the teaching style actually produces the effects described is an empirical question. These statements should be regarded as hypotheses.

The teacher himself will be an active inquirer, making the learning process itself a subject of his inquiry. Teaching will be the means by which the teacher himself learns; he will be as actively engaged in learning as his students.

He will stress openness of inquiry. He will not make arbitrary distinctions between knowledge and living, between understanding and being, between social importance and personal relevance. He will help students seek knowledge and understanding; he will not think of teaching as giving knowledge and understanding.

The character of his relations with students will also be changed. He will appeal to the authority of free inquiry rather than to the authority of persons. He will not impose his greater knowledge or deeper insight on students, but will rely on their perceptions of his competence to stimulate them to seek him out as a guide.

From the Student's Perspective

The characteristic behaviors of students taught with heuristic teaching styles will also take many forms. The student will be an active inquirer rather than a passive recipient of knowledge. He will see the process of learning as a way of achieving his most significant personal goals. His definition of his goals, of what in life will have significance for him, will emerge out of the processes of learning. He also will not make an arbitrary distinction between being and learning, between personal relevance and education, between meaning and personal significance.

He will assume responsibility for his learning. He will not need to be goaded to learn, since the significance of learning will have become intimately personal for him. He will view education as a means of achieving his goals. He will see teachers not as threats to his personal integrity but as helpers in achieving and enhancing it.

Admittedly, these descriptions represent ideal characterizations of teachers and students. Realists, familiar with today's schools, will despair of achieving a system in which there are large numbers of such teachers and students.

The purpose of the Center's research and development in this problem area is to initiate progress toward this goal. It will not be achieved in the immediate future. But it can be attained within a reasonable span. For those who doubt that changes toward such a goal can be wrought, we point to the technological and social revolutions occurring in our society. These potent social forces can be made to help in the development of schooling that emphasizes heuristic teaching.

Heuristic Teaching and the Open School

The character of the American school must change in the coming decades if education is not to be overwhelmed by the new computer revolution, if education is to contribute to the development of the most significant aspects of childrens' lives. The experience of the past decade has made it obvious that curriculum innovations do little to produce profound changes in schooling. The most imaginative innovation in curriculum can be subverted into a pedestrian analysis of subject matter by a teacher who does not understand its purposes or possess the motivation and skill to teach toward its goals. A set of experiments designed to stimulate students to inquire becomes merely another set of exercises in the hands of the teacher insecure with inquiry. Comprehensive schemes for organizing subject matter are of little interest to the teacher with little zest for learning or skill in making learning a challenge rather than a chore.

Even if many teachers were skillful and motivated enough to use hueristic teaching styles, the present organization of the schools would interfere with their use. Teaching functions are undifferentiated in present-day schools, so that one teacher must perform many functions. Even though a teacher may be skillful enough to perform them, the most demanding--heuristic teaching--is likely to be slighted because the others consume so much of his energy. Moreover, the present organization of teaching does not permit teachers unskilled at heuristic teaching to avoid it, any more than it permits those unskilled at didactic teaching to avoid it.

Also, the prevailing emphasis on didactic teaching has created a generation of administrators and parents who equate learning with the absorption of information. Any change in teaching styles, particularly when it places greater responsibility on the student for his own learning and stresses inquiry, will require changes in the attitudes of both administrators and parents.

Two kinds of changes are required. First, heuristic styles of teaching must be introduced into the schools to supplement the didactic mode.

Second, schooling must be organized to facilitate both the consequences of the computer revolution and the introduction of heuristic teaching styles, creating what we have called the "open school."

The following excerpt[2] describing the Center's programs on Heuristic Teaching is from the Center's Fourth Annual Report:

> The general purposes of the Heuristic Teaching program are threefold: (a) to define heuristic teaching functions in education; (b) to understand the psychological processes of heuristic teaching and learning; and (c) to develop means of promoting heuristic teaching and learning in schools. The program was established in April 1968, growing directly from earlier Center work on microteaching and the technical skills of teaching approach

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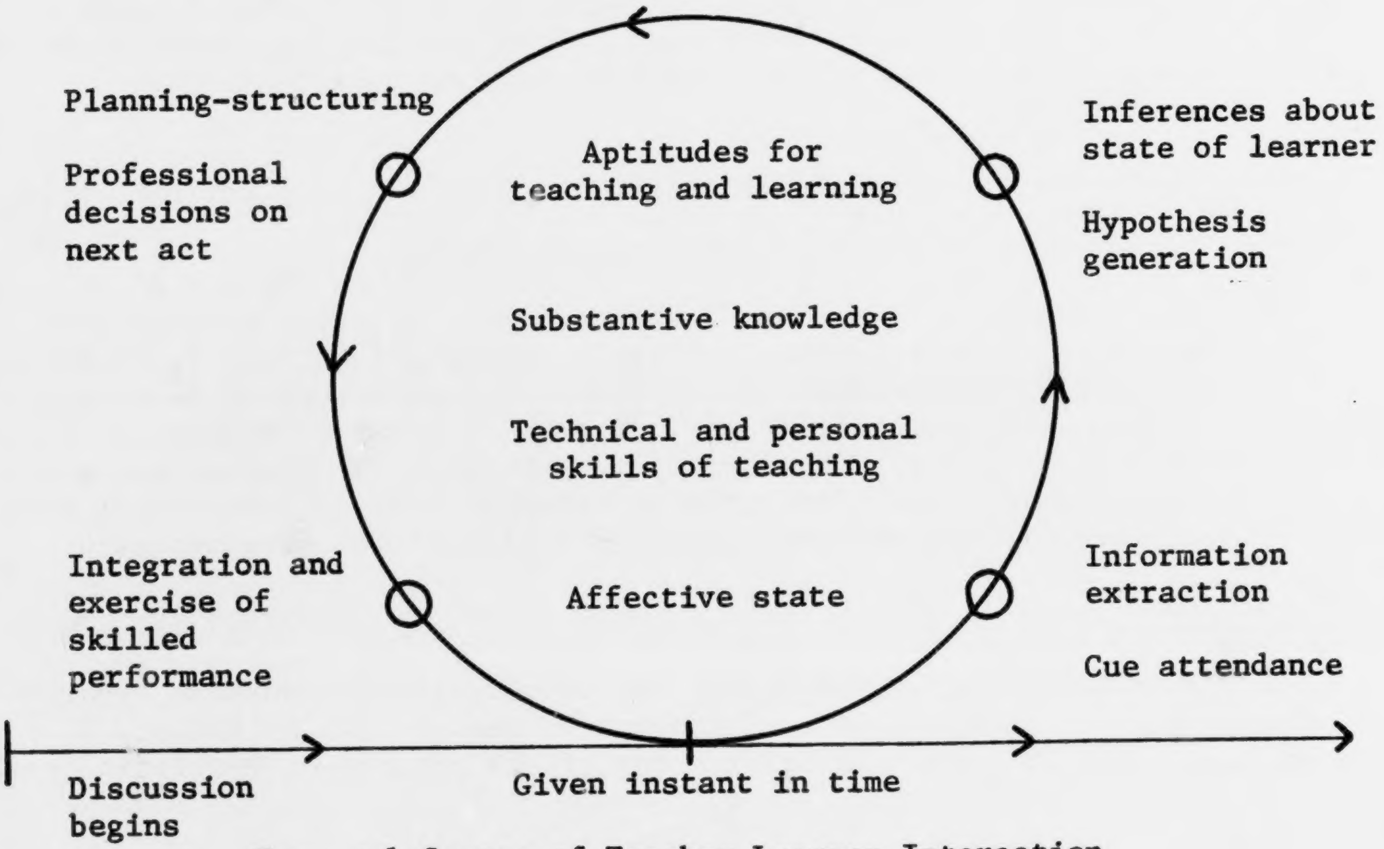
[2] Stanford Center for Research and Development in Teaching, Fourth Annual Report (August 1969). This portion was written by Richard E. Snow, who succeeded Dr. McDonald as Director of the program on Heuristic Teaching.

to teacher training as well as other research on cognitive and affective interactions in the teaching-learning process. The term "heuristic" is meant to suggest an emphasis on inquiring, inductive, hypothesis-generating modes of instruction rather than on fact-dispensing, deductive, expository modes. While the program's research deals with teaching and learning in general, the hope is to develop new, more adaptive, and functional forms of human teaching in relation to other components of the instructional system.

It is possible to look forward to an increasingly integrated theoretical framework, linking the program's research activities in substance as well as administratively, and to envision an increasingly diversified array of products resulting from the program's developmental efforts. At present, however, such a framework can be only roughly outlined. It must remain flexible enough to incorporate new findings and developments as they accumulate or to change drastically as the resulting new knowledge dictates.

Some of the elements of the growing theoretical framework, and some of the relations between current projects, are schematized in the following diagram. The diagram identifies cognitive events that are presumably involved in heuristic teaching behavior. One can assume, for example, that at some given instant in an ongoing group discussion a teacher attends to significant cues regarding the course of discussion, makes inferences about the state of confusion in some problem faced by the students, decides on a form of questioning or comment designed to open new aspects of the problem, and skillfully inserts such questions or comments


Planning-structuring
Professional decisions on next act
Aptitudes for teaching and learning
Inferences about state of learner
Hypothesis generation
Substantive knowledge
Technical and personal skills of teaching
Integration and exercise of skilled performance
Affective state
Information extraction
Cue attendance
Discussion begins
Given instant in time

Temporal Course of Teacher-Learner Interaction into the stream of discussion. It can further be suggested that both the current course of classroom events and the teacher's earlier acquisition of skills will have been influenced by that teacher's aptitudes for teaching (and for learning to teach), by his substantive knowledge and repertoire of technical and personal skills, and by his affective or temperamental state at any given moment.

On a somewhat larger time scale, the cycle can be used to characterize a teacher's behavior from day to day. A teacher summarizes the results of one day's discussion, observing particular points of success or concern. He makes inferences about the progress of comprehension for individual students or for the group as a whole, decides upon strategies for the conduct of further discussion, and as the next meeting proceeds, the formulated plan is executed.

Application of the schema presented above is not limited to the behavior of a teacher as a group discussion leader; it may be used to represent teaching processes in monitoring and critiquing an individual student's independent study report, in conversations with a parent, in preparing materials for weekly units, or in constructing an achievement test. Further, it is not meant to restrict attention to clearly cyclical patterns of teacher-learner interaction, for among the most important examples of heuristic teaching behavior may be the identification and pursuit of new ideas happened upon serendipitously in the course of lecturing. The diagram focuses on teaching; left implicit are comparable processes on the learner's side, which are no less important as both interacting and dependent variables for most of the research on teaching currently underway or envisioned for the program. The schema thus serves only roughly as a guide for this program report, showing how the concerns of the various projects of the Heuristic Teaching program may be related within the cognitive operations of the individual teacher.

While the papers collected here are intended primarily for use in planning ongoing Center work, it is hoped that their dissemination in this form may serve wider goals in promoting improved research and development in teaching.

PART II: RESOURCE PAPERS

HEURISTIC TEACHING IN MATHEMATICS: A REFORMULATION

Jon L. Higgins[1]
Stanford University

The state of heuristic teaching as an area of study in mathematics education has never been at a lower ebb. Few, if any people in the field know with certainty what heuristic teaching in mathematics encompasses. Of the books dealing with mathematics instruction published in the last five years in this country, only one even references heuristic teaching in its index. The notion of heuristic teaching in mathematics is at present very confused and poorly defined. In this paper we shall trace the sources of this confusion, and attempt to reformulate a new definition of heuristic teaching which lessens some of this conflict.

In particular we shall seek to identify a rather broad category of teaching techniques as heuristic. We will attempt to avoid making value judgments about the efficacy or sufficiency of this category. At the present time we simply do not have information which is complete enough to allow for enlightened statements of efficiency for teaching procedures. This situation is compounded by the confusion about the nature of heuristic teaching. If a reformulation of heuristic teaching in mathematics can remove some of this confusion, then we may be ready to focus our research toward providing such information. For this paper, however, we will not assume that heuristic teaching is either good or bad, but only that it is distinctive.

Similarly, we can see no reason to assume that the category of heuristic teaching need be so broad as to encompass all necessary teaching functions. Heuristic teaching should be a way to classify some teaching acts, but not all teaching necessities. We shall thus be alert to limitations of heuristic teaching in mathematics in the hope that there are other teaching categories which do not share these same limitations.

Defining heuristic teaching in mathematics education is complicated by the fact that the term "heuristic" has a specialized meaning and lengthy history in the field of mathematics. To a mathematician the word "heuristic" has an infinitely richer meaning than simply discovery. The foremost advocate of heuristic today, George Polya, reminds us that

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[1] Now at Ohio State University.

> heuristic, or heuretic, or 'ars inveniendi' was the name of a certain branch of study, not very clearly circumscribed, belonging to logic, or to philosophy, or to psychology, often outlined, seldom presented in detail, and as good as forgotten today. The aim of heuristic is to study the methods and rules of discovery and invention.
>
> Modern heuristic endeavors to understand the process of solving problems, especially the mental operations typically useful in this process. It has various sources of information, none of which should be neglected. A serious study of heuristic should take into account both the logical and psychological background, it should not neglect what such older writers as Pappus, Descartes, Leibnitz and Balzano have to say about the subject, but it should least neglect unbiased experience. Experience in solving problems and experience in watching other people solving problems must be the basis on which heuristic is built.[2]

Thus, in mathematics especially, heuristic seems inexorably bound to problem solving. Polya has devoted the major portion of his writing and lecturing to an explanation and analysis of problem-solving techniques. Much of his writing can be characterized as case histories of solutions. The most concise formulation of the heuristic which he has synthesized from these many case histories is contained in his most popular book How To Solve it. He presents the heuristic as a list of questions which one should ask himself as he tries to solve a problem. The list begins:

1. What is the unknown? What are the data? What is the condition?
2. Is it possible to satisfy the condition? Is the condition sufficient to determine the unknown? Or is it insufficient?
3. Have you seen the problem before? Or have you seen the same problem in a slightly different form?
4. Do you know a related problem? Do you know a theorem that could be useful?
5. Look at the unknown! And try to think of a familiar problem having the same or a similar unknown.

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[2] George Polya, How To Solve It (Garden City, N. Y.: Doubleday Anchor Books, 1957), pp. 112, 129-130.

6. Here is a problem related to yours and solved before. Could you use it? Could you use its result? Could you use its method? Should you introduce some auxiliary element?
7. Could you restate the problem? Could you state it still differently? Go back to definitions.
8. If you cannot solve the proposed problem, try first to solve some related problem. Could you imagine a more accessible related problem? A more general problem? A more special problem? An analogous problem?

And he continues from there.

When faced with the term "heuristic teaching," the mathematics educator must reconcile two possible meanings. Does this mean the teaching of problem-solving methods and therefore relate primarily to content? Or does it have to do with teaching procedures? If we are talking about procedures when we mention "heuristic teaching" are we limited to those procedures which the teacher uses when teaching about problem solving, or do we include more general procedures?

Instruction and Content

Let us agree that by heuristic teaching in mathematics we are referring to a category of teaching procedures which are applicable to a wide range of mathematics content. Furthermore, let us attempt to relate heuristic teaching as closely as possible to the meaning of heuristic in mathematics. One possible way to do this is to define heuristic teaching in mathematics as a category of instructional methods which make primary use of one or more problem-solving strategies in mathematics.

Now strategies of problem solving are only minimally relevant apart from problems. If our definition is to have any import at all we must assume and find support for the assumption that a nontrivial part of school mathematics content can be approached as if it were a problem. This requirement alone may require a major shift in the teacher's philosophy and view of the teaching situation. If content is to be approached as if it were a problem, then the classroom must change from a place where information is sought. A student has a problem when he has been given the description of something but does not yet have anything that satisfies the description. More explicitly (a) he has a clearly defined goal that he desires to attain; (b) the path toward the goal is blocked and his habitual responses and fixed patterns of behavior are not sufficient for removing the block; and (c) he can discriminate between alternative courses of action and deliberate about their feasibility.[3] Thus, to approach mathematics content as a problem the mathematics content must be established as a goal related to possible courses of action. The forming of the goal is related to the establishment of objectives; the related courses of action to the determination of hierarchical prerequisite knowledge. Each of these areas provides a wealth of research questions related to teaching. In particular, the form of the statement of objectives would seem particularly important to the establishment of content-as-problem. A statement like "Today we will learn how to compute the distance between two points in a Cartesian coordinate plane by using the Pythagorean theorem" destroys any content-as-problem approach since it establishes a goal but then proceeds to remove the blocking of that goal by removing the need to discriminate between various courses of action. In this case, a far simpler goal statement seems much more preferable, viz.: "Let's see if we can figure out how to compute the distance between any two points in a Cartesian plane." What is the relationship of cognitive set or advanced organizers to such goal statements? It would be valuable to explore the form of teacher goal-statements which lead to the widest variety of problem-solving activity for the greatest number of students.

Much of the ability to present content as problems depends upon just this ability to break mathematics into "let's-see-if-we-can-figure-out" blocks. This is the most easily done by asking the student to redevelop or recreate many of the principles which form the body of mathematics. This recreation was a formidable if not impossible task when the teacher used traditional mathematics curricula. These curricula viewed mathematics as little more than a collection of facts and principles. But modern mathematical definitions, concepts, and principles. As a result, the possibility of presenting mathematics content as problems has come within closer reach.

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[3] Kenneth B. Henderson and Robert E. Pingry, "Problem Solving in Mathematics," in The Learning of Mathematics: Its Theory and Practice (Washington, D.C.: The National Council of Teachers of Mathematics), p. 230.

But we must realize that the concern of heuristic is not just obtaining an answer to a problem. Heuristic seeks generalities from problem solutions. The last category of Polya's How To Solve It list is entitled "looking back." He admonishes the problem solver to "examine the solution obtained. Can you check the result? Can you check the argument? Can you derive the result differently? Can you see it at a glance? Can you use the result, or the method, for some other problem?"[4]

It is this looking back which is all too often ignored in the usual problem-solving sessions in many mathematics classrooms. The result is an almost totally answer-oriented student. He does not want to know about the structure of mathematics. He cannot be bothered with basic laws and principles. He will only grudgingly tolerate explanations of why a particular mathematical procedure works. We have conditioned him to a belief that, in mathematics, answers are all-important. Answers are almost always the goal of mathematics tests, not discussions or explanations. Thus he seeks not the "why" of a solution but the "how," the tricks, the manipulations.

Presenting content as problems, then, is not the same as presenting a series of answer-seeking exercises. The content-problems of heuristic teaching must look back over content, techniques, and concerns that have previously entered into a student's experience. They must look forward, as well, to new relationships and new problems. What does this mean in terms of lesson design and sequencing for heuristic teaching? Let us look at some examples of lessons constructed for heuristic teaching.

Logical Construction and Instructional Procedures

Heuristic teaching has been considered by some mathematics educators as a teaching procedure which makes use of a series of directed questions.

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[4] Polya, How To Solve It, p. xvii.

"By (heuristic teaching) we mean a method which aims to lead the student, through well-chosen questions, to discover facts, information, relationships and principles for himself."[5] This may well have arisen from a confusion about whether Polya's lists of questions formed a method or a goal. (Indeed, much of what makes Polya a master teacher is this intimate intermingling of method and goal.) The difficulty is compounded by the fact that no criteria or guidelines were established to select or evaluate "well-chosen questions" or well-chosen sequences. The following excerpt from the 21st Yearbook of the National Council of Teachers of Mathematics is an example of what was considered heuristic teaching.

> First lesson on circles: "If you wished to construct another circle equal to this one, what would you measure? Consider this circle with the 5-inch radius. With respect to the circumference, where would a point three inches from the center be? 8 inches? 5 inches? What are your conclusions with respect to distance from the center and the circumference? Here are two equal circles, 0 and 0'. Mark off equal arcs AB and A'B' and draw the radii. What would you expect to be the relationship between angles AOB and A'O'B'? What is one method of proving two angles equal in two equal circles? What do you think is true about chords AB and A'B' in these circles? How do you usually prove two line segments equal? But there are no triangles here! How would you draw lines to make the triangles which you mentioned?"[6]

Consider the sequence of questions in this example of heuristic teaching. Do they bear any relationship to the list of questions that comprise Polya's heuristic? To be sure, we are faced with a problem: how can a given circle be duplicated? Polya would begin by exploring the given data and conditions; would continue by looking for similar problems (have you solved problems where other geometric figures were duplicated?); and would try a simpler problem (how can you construct a circle if the exact size is not important?). The questions in our example bear little relationship to any general problem-solving techniques. Teaching by simply asking a series of direct questions would, of and by itself, certainly not seem worthy of the designation "heuristic teaching." What we should seek in a definition of heuristic teaching is a relating of the logic of the teaching sequence to the logical patterns of problem solving. Let us consider a few of these patterns to see how they can determine logical instructional sequences.

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[5] Charles H. Butler and F. Lynwood Wren, The Teaching of Secondary Mathematics, 3rd ed. (New York: McGraw-Hill Book Company, 1960), p. 167.

[6] Irving Allen Dodes, "Planned Instruction," in The Learning of Mathematics: Its Theory and Practice. (Washington, D.C.: The National Council of Teachers of Mathematics), p. 317.

1. One problem-solving technique involves guessing an answer, working out its consequences and by comparing these with the original conditions of the problem, improving the original guess. The implications of this heuristic for classroom teaching strategy are fairly obvious. Suppose we want to teach students how to square a binomial. We want an equivalent name for $(x + 3)^2$. We ask for a guess; a common response would be $x^2 + 9$. But now we must look for the consequences of our guess. Suppose the variable x has the value 1. Then the value of

$$(x + 3)^2 = (1 + 3)^2 = 4^2 = 16$$

and of

$$x^2 + 9 = 1^2 + 9 = 1 + 9 = 10.$$

Here is a case where these two expressions do not name the same number. Somehow $x^2 + 9$ is "too small." Can we improve our guess? How about $(x + 3)^2 = 2x^2 + 9$? Then, if $x = 1$

$$(x + 3)^2 = (1 + 3)^2 = 4^2 = 16$$

and

$$2x^2 + 9 = 2 \cdot 1^2 + 9 = 2 + 9 = 11.$$

This seems a little better. How about $(x + 3)^2 = 7x^2 + 9$? Then, if $x = 1$

$$(x + 3)^2 = (1 + 3)^2 = 4^2 = 16$$

and

$$7x^2 + 9 = 7 \cdot 1^2 + 9 = 7 + 9 = 16.$$

Success! But what if we vary the problem slightly? Have we gained any insight which would let us expand expressions like $(x + 4)^2$ or $(x + 178)^2$? And what happens if the variable x has a value other than one? These variations will lead to many more modifications of our original guess before the problem is solved.

2. Sometimes a problem-solving technique involves finding a simpler related problem. In some cases this simpler problem may actually be a part

of the original problem with certain conditions ignored. This heuristic adapts itself to instructional strategy particularly well when the general objective is the exploration of a relatively wide area of topics. Suppose we want to teach a sequence of theorems about secants, tangents, and chords of circles. Many of these ideas can be subsumed in the problem "given three noncollinear points, can we find a way to construct a circle which will pass through these three points?"

To the uninitiated, this is not a trivial problem. A trial-and-error approach will usually require many attempts before solution, and if a circle is fit to the points it usually does not suggest a definite procedure. What we need is some way to locate the center of the required circle. But suppose we take a simpler related problem. Can we construct a circle through any two points? Compare the solutions of all the members of the class -- are they identical? Do they form a pattern? Suppose we put two or three of these simple problems together. After all, in our original problem of three points we have three possible combinations of pairs of points. What arcs and lines do the patterns suggest; what relationships seem to exist between these arcs and lines? Can we establish these relationships deductively from what we already know?

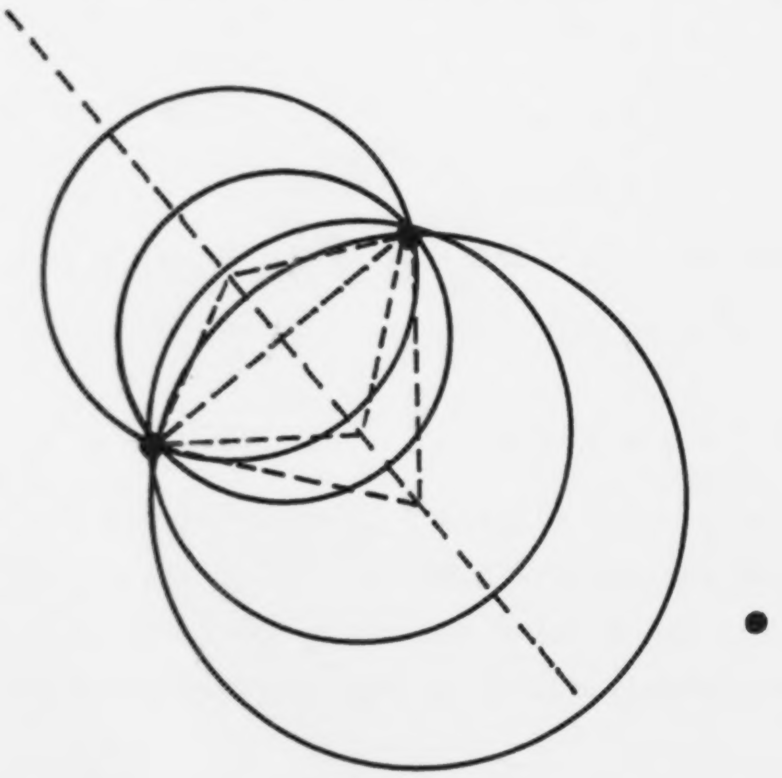

Fig. 1. The 3-point problem can be solved as two 2-point problems by considering the pattern of possible circles.

3. Polya discusses decomposing and recombining as important mental operations, and as an important technique in problem solving. We can often consider a problem as a complex situation made up of many details. We begin by focusing upon the details individually, decomposing the whole into its parts. In this process it may be necessary to go back to the original definition of a term, and to introduce new elements involved in this definition. We then attempt to reorder and recombine our new original and new elements in some new and different way.

This problem-solving technique is useful in designing instructional procedures where our ultimate aim is one of classification or definition on the basis of a classification. Suppose, for example, that we wish to explore the definition of similarity in geometry. We could generate a set of triangles by considering many different images of a given cardboard triangle projected by an overhead projector at varying distances and angles from the screen or blackboard. The problem to be posed is to form sets of triangles and then to describe some criteria for including or excluding triangles from this set. The ensuing class discussion should proceed along the decomposition and recombining approach in a very natural manner, eventually generating the essence of the similarity definition.

It is always possible that students will stop short of an accepted definition when this technique is employed. When this happens, the role of the teacher should not be to force the accepted definition upon students, but to lead them to explore the consequences of their own definition. Studying the consequences of a particular answer is always good problem-solving technique. For example, students may be satisfied with a statement like "two figures are similar when corresponding angles are congruent." There is nothing incorrect with this statement, but it defines quite a different kind of "similarity" than that usually meant by mathematicians. By this definition all of the rectangles in Figure 2 would be "similar." (What would happen for five, six, or seven-sided polygons?) The choice here is not a matter of deciding between a right or wrong answer, but deciding whether or not to accept the consequences of that answer.

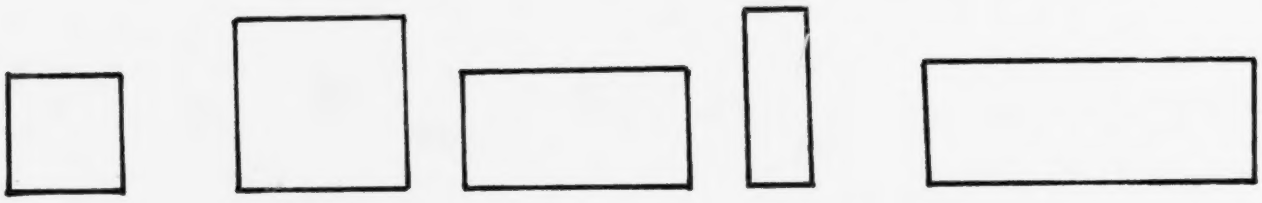

Fig. 2. Are these rectangles similar?

The most obvious effect of these examples is their effect upon the organization of instructional sequences. They provide the beginning of a set of logical principles for the construction of classroom lessons and instruction. The logic of teaching is a vital component of any instructional theory. But to come to fruition such a theory must encompass not only the logic of teaching, but the actions of teaching as well. What do our examples say about the actions of the teacher during heuristic teaching? At first inspection they make little or no determination of action. One can deliver a lecture where the problem-organized content is developed by reference to simpler related problems just as well as a student-centered discussion. A similar statement could be made about each of our other examples.

But heuristic does imply some determination of instructional action as well as logic. To understand this we must return once again to an examination of the basic meaning and principles of heuristic. We will do this by comparing our original example of heuristic teaching from the NCTM 21st yearbook with a statement about heuristic from the field of computer simulation of human problem solving.

Uncertainty and Heuristic Teaching

Look again at the lesson on circles (page 18) which served as an example of the old notion of heuristic teaching. It has little to do with problem-solving techniques, as we have seen. But it differs from the instructional strategies we have just discussed in yet another important way. It is painfully apparent in the circles lesson that the teacher has predetermined the correct solution to the problem of duplication. Furthermore, this solution and only this one solution is determined by both the sequence and specificity of the teacher's questions. The student is immediately directed to consideration of metric geometry in the question "what would you measure?" The radius is specified by the teacher in the example used.

It is not sufficient to consider heuristic teaching simply as a fancy phrase for discovery teaching. Most of what passes for discovery teaching could (like our example) be more correctly described as "uncovery teaching." An inductive sequence of steps is constructed around a particular problem solution or concept organization. If the teacher knows of only one means to the end, the task of the student becomes one of uncovering this particular solution or organization. The option of unusual solutions or organizations is not entertained, and the discovery lesson degenerates into a game of "guess what's on my mind."

But the freedom to consider alternate possibilities lies at the heart of heuristic. This has been recognized as a cardinal principle even in the area of research in the computer simulation of human problem solving. Geleunter and Rochester put it cogently:

> We shall consider that a heuristic method (or a heuristic, to use the noun form) is a procedure that may lead us by a shortcut to the goal we seek or it may lead us down a blind alley. It is impossible to predict the end result until the heuristic has been applied and the results checked by formal processes of reasoning. If a method does not have the characteristic that it may lead us astray we would not call it a heuristic, but rather an algorithm.[7]

How different this is from the usual teaching procedure where an avowed purpose of the teacher is to prevent children from going astray! If we are to make heuristic teaching compatible with heuristic, our definition must not only allow, but demand, the flexibility to entertain uncertainty and alternate-solution approaches. This may be, in practice, the area of heuristic teaching which will be hardest to achieve.

The "unusual solutions" option necessary for heuristic teaching appears to be something that is particularly hard to incorporate in written text materials. Textbooks which utilize a discovery approach tend, paradoxically, to lock both the student and the teacher to a programmed sequence of steps.

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[7] H. L. Geleunter and N. Rochester, "Intelligent Behavior in Problem-Solving Machines," I.B.M. Journal of Research and Development, 2 (October 1958), p. 337.

The provision of alternate discovery sequences is an overwhelming task. (One mathematics curriculum group estimated that to provide a reasonable number of options for a first-year algebra course would require a text of 50,000 pages!) Enough steps must be provided to insure that the student has the necessary prerequisite knowledge so important in mathematics. Yet possible shortcuts cannot be clearly marked for fear of giving more authoritarian guidance.

The result of this dilemma is to place more responsibility for determining teaching materials and sequences in the hands of the teacher. But how are teachers to be trained to accommodate uncertainty and alternate solutions? The movement in the past decade to strengthen a teacher's preparation in subject matter by raising the number of required hours of mathematics for purposes of the credential attempts to make this accommodation. Certainly, if teachers are to be able to entertain the possibilities of alternate solutions in their classroom, they must know a great deal of mathematics. In particular, they must know very much more mathematics than they will actually teach. But what kind of mathematics should this be? Typical mathematics courses in a teacher training program do little to explore a given area in more depth, but generally introduce the prospective teacher to new areas of mathematics instead. These new areas are necessary in light of new content being introduced to school mathematics, but they are not sufficient for freeing the teacher from one rigid way to approach mathematics. We must find ways to do more to teach teachers to cope with uncertainty.

When a teacher can face uncertainty, the results can be astounding. In an article in the Arithmetic Teacher, Joan R. Needleman describes a seventh-grade lesson on locating points in a plane. Given a point on the blackboard, and faced with the problem of describing its location, a student made the unexpected suggestion that it could be located between regions determined by two oblique coordinate lines as suggested in Figure 3.

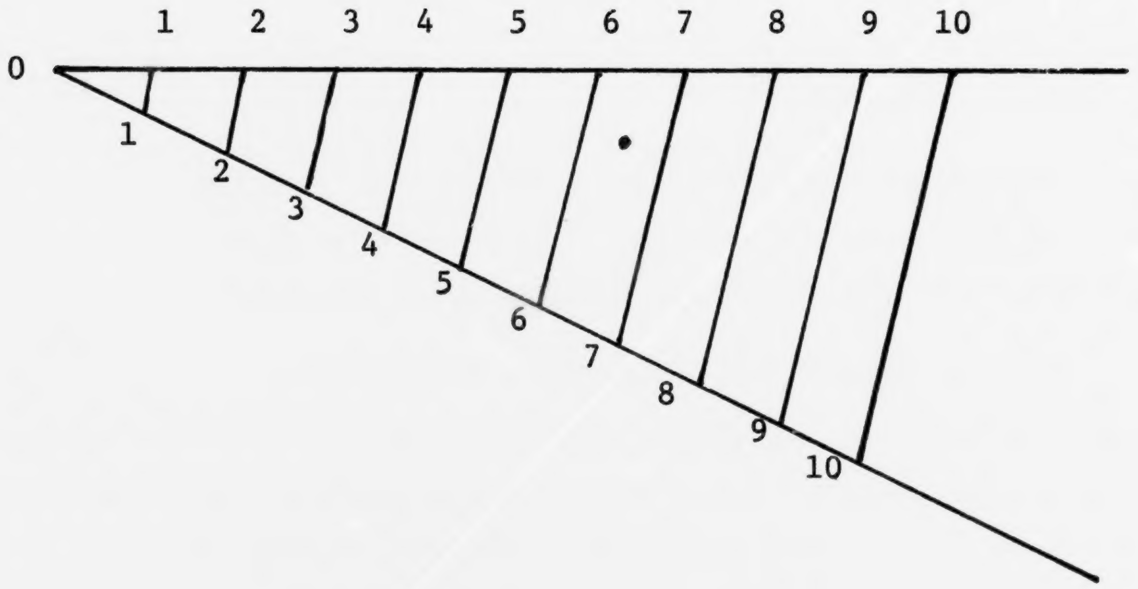

Fig. 3. The point is located in the region determined by the 6th and 7th units.

Obviously, a teacher who is concerned with preventing children from missing the correct solution would have stopped the procedure at this point. But on the basis that "mathematics is a game, and that mathematicians can make different sets of rules and then play the game according to the rules selected," this teacher let the class proceed. The next student suggestion was the following figure, locating the point on a particular ray.

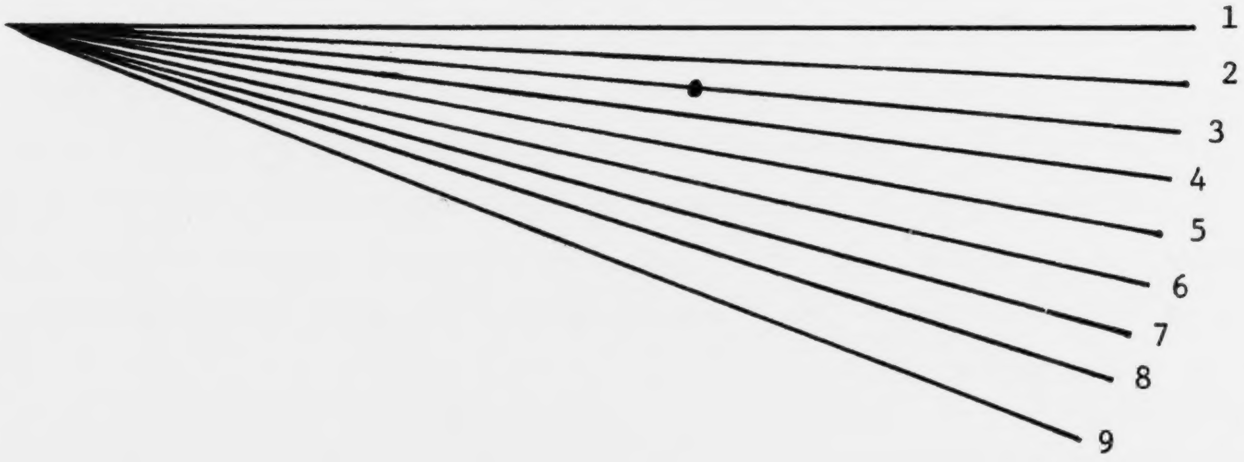

Fig. 4. The point is located on ray number 3.

And the final suggestion was that two kinds of information were needed to locate the point: the number of the ray, and the distance of the point from the origin of the ray.[8]

By accommodating uncertainty this teacher was rewarded with a very successful but most unusual solution! It is precisely this freedom of response which is a most necessary condition for heuristic teaching.

Heuristic Teaching and Student Involvment

One way to increase the probability of alternate-solution approaches is to increase the input of ideas fed into the problem situation. This argues, in turn, for involving as many different sources of ideas as possible. Some authors distinguish between teaching methods which consider the class as a whole and methods which point to students as individuals.[9] Only the latter are termed "heuristic"; group processes are called "genetic." There is very little in the nature of heuristic that would indicate that this is a useful distinction. To be sure, problem solving in mathematics may be an intensely personal matter; yet at the same time few problem solvers would deliberately remove themselves from the input of other great thinkers and writers. Few mathematicians would be willing to forego opportunities for contacts with either their libraries or their colleagues! Why should the heuristic teacher deny students the opportunity to consult with their libraries or their colleagues? To be sure, the kinds of ideas offered by a fellow student will be rough and unsophisticated, but can we be sure that the student is any better able to use a precise, powerful, and sophisticated idea from a mathematician? The sophisticated idea of the mathematician is treasured for its brilliant logical leap; a much more pedestrian and detailed development of ideas may well be more suitable for pedagogical purposes. In sum, then, the searching process common to so much of heuristic would argue that heuristic teaching should make great use of group processes.

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[8] Joan R. Needleman, "Discovery Approach - Polar Coordinates in Grade Seven?", The Arithmetic Teacher, 14 (November 1967), pp. 563-565.

[9] Harold P. Fawcett and Kenneth B. Cummins, The Teaching of Mathematics from Counting to Calculus (Columbus, Ohio: Charles E. Merrill Publishing Company, 1970), p.33.

At the same time, problem solving is in an ultimate sense an extremely individual matter. The mathematician R. L. Moore points out that no one of personal integrity who is in the process of solving a problem wants to be given outright the solution to the problem as done by another person. Moore invites and encourages his students to leave the classroom if they are not ready to see the solution of the problem under discussion. His students have been known to run frantically from the classroom, hands on ears, and not to return for weeks until they could reappear with their own solution to the problem in hand. If we are to pursue the matter of heuristic teaching we must be open to such unorthodox activities. We must especially be prepared to abandon the rather preposterous assumption that the most valuable problem-solving activities can only occur within the confines of a classroom. And we must realize that problem solving is ultimately an individual process. The important question is how we can get students as individuals involved in the problem at hand. Any definition of heuristic teaching must seek to maximize student action and participation in the teaching process.

There is some probability that a student will become involved in almost any kind of teaching act. It seems reasonable to assume however that the value of this probability rises in direct proportion to a rise in the extent to which students participate overtly. Thus, while it is entirely possible that a student will become caught up in a skillfully delivered lecture, the chances of his involvement would seem to be much greater (though not certain) if he is manipulating laboratory apparatus. Similarly, working together with a small group of his peers to solve a problem may for the younger student result in much more involvement than being isolated to struggle with the problem by himself.

These are assumptions which need to be investigated in a systematic way. We have invested much energy in observing what the teacher does in a classroom. What does a child do during a lesson? Are his observable actions related in quantity or in quality to his learning? What teacher actions result in desirable student actions? What kinds of actions encourage the generalizations and insights that we call discovery?

Summary

We have begun a reformulation of the concept of heuristic teaching in terms of mathematical heuristic or problem-solving methods. In the process we have seen this reformulation touch almost every aspect of classroom instruction: from the organization of content and lesson sequences to the determination of teacher-student interactions, to the evaluation of student learning and response. By its very nature, heuristic does not uniquely determine one particular approach in any of these areas, just as it does not relate to one particular problem-solving technique. Heuristic does tend to define broadly a category of instructional methods. This category is delineated by four general characteristics of heuristic teaching. We have seen that heuristic teaching:

1. Approaches content through problems.
2. Reflects problem-solving techniques in the logical construction of instructional procedures.
3. Demands the flexibility for uncertainty and alternate approaches.
4. Seeks to maximize student action and participation in the teaching process.

Any teaching technique which meets all of these criteria may be called heuristic teaching. At present, the number of teaching practices which would qualify is distressingly small. In particular, characteristics 1 and 3 seem to be especially restrictive. It is far from clear that all mathematics content can or should be approached as a problem. (How, for example, can the definition of the trigonometric functions be approached as a problem?) Nor does it always seem possible to allow for alternate solutions in the advance preparation of teaching materials. Yet at the same time these are the characteristics that give heuristic teaching so much of its distinction. Under this reformulation, heuristic teaching regains much importance as a field of study, development and research. Perhaps Polya states its importance most elegantly:

> A great discovery solves a great problem but there is a grain of discovery in the solution of any problem. Your problem may be modest; but if it challenges your curiosity and brings

into play your inventive faculties, and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. Such experiences at a susceptible age may create a taste for mental work and leave their imprint on mind and character for a lifetime.[10]

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[10] Polya, How To Solve It, p. v.

HEURISTIC SCIENCE TEACHING

Robert Bridgham
Stanford University

Science teaching is teaching of or about science; but what is heuristic science teaching? One dictionary[1] indicates that the meaning of "heuristic" is opposite to that of "ostensive." "Ostensive," according to a second,[2] means "manifestly demonstrative." A heuristic act, then, is not a demonstration of what has been made manifest, not a public act of showing what has become obvious, but a personal act of revealing what had been hidden.

Who is the actor in the act of heuristic science teaching; who is the person for whom the teaching is heuristic? If it is the student (or the teacher as a student), then teaching is heuristic when it helps him to address problems arising in or from science. If it is the teacher, then teaching is heuristic when it helps him to address problems arising in or from science teaching. It is possible (and certainly desirable) that teaching may be heuristic for both student and teacher. However, since the problems of concern are not necessarily the same for both, it is not clear that what is heuristic for one will also be heuristic for the other. We need some sense of what would be heuristic science teaching from the student's point of view and of what would be heuristic from the teacher's.

Another definition of "heuristic" (from still a third dictionary[3]) indicates that whatever is heuristic serves "to guide, discover, or reveal" and, specifically, is "valuable for stimulating or conducting empirical research but unproved or incapable of proof." Once again the heuristic act is seen as pointing to something hidden which if revealed would count as a discovery. But this narrows considerably the definition of heuristic teaching, for, as Michael Polanyi reminds us, "nothing is a problem or discovery in itself; it can be a problem only if it puzzles and worries somebody, and a discovery only if it relieves somebody from the burden of a problem."[4]

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[1] The Dictionary of Philosophy (New York: Philosophical Library, 1942).

[2] The American College Dictionary (New York: Random House, 1956).

[3] Webster's Third New International Dictionary (Springfield, Mass.: G. and C. Merriam Company, 1961).

[4] M. Polanyi. Personal Knowledge (New York: Harper Torchbooks, 1964), p. 122.

Real Problems

The first condition for heuristic teaching is that the problems addressed be problems indeed. Students (and teachers) must be perplexed and must care about their perplexity. The science teacher must lead his students to see phenomena problematically, as offering problems for them. Similarly, the teacher must see teaching as problematic. Consider, for example, three classroom treatments of Mendel's work.

The first (and most common) treatment is simply to recapitulate Mendel's crosses of peas. The characters studied, the data reported, the inferences drawn are all described in turn. The teaching has the character of a demonstration; it is the opposite of heuristic teaching.

A second approach to Mendel's work starts with the question apparently asked by him: "What is the basis of inheritance in peas?" The teacher provides some background on the observable variations in the characteristics of pea plants, along with some information about the possibility of breeding "pure strains." Students are asked to suggest experiments that might shed light on Mendel's question; Mendel's experiment is offered as an example of an experiment that one might do; Mendel's data are presented and students are asked "how can we interpret this?" The teaching has the appearance of an inquiry but is not an inquiry. Most of the students don't care how the question is answered and take the classroom activity to be either a form of intellectual exercise (like filling in a crossword puzzle) or an approved form of social interchange (like the questions and answers of strangers at a cocktail party). The "problem" is isolated from any genuine problem the student might face.

It has an artificial beginning, an artificial end, and since it is unrelated to the larger problems that have characterized biological thought or the immediate problems that students may have, it can be dealt with at any time. At its best this treatment of Mendel's work is like a "finger exercise"; at its worst it is a caricature of inquiry.

A third treatment of Mendel's investigations would begin with some questions about the sources of variability in populations (human populations would receive particular attention). The approach to these questions could be practical -- can we arrange the "optimization" of the characteristics of entire populations? -- or it could be explanatory -- how is it that variability in a species is maintained at all, and how is it that variability doesn't destroy a species' identity? In either case we would be concerned with the rival claims of environmental effect and inheritance and, in order to evaluate these claims, would want to know the mechanisms of inheritance and environmental effect. Mendel's work could then be examined (using either of the formats previously discussed), but it would be seen, not as an end in itself, but as the source of a heuristic conjecture.

Is the mechanism of inheritance first sketched in Mendel's work applicable to other and very distantly related species? To other characteristics? Is there an identifiable something in the living organism that corresponds to one of Mendel's "factors?" Following this line of inquiry the student is brought to the growing edge of modern biology. Following it far enough to see the conjecture grow in complexity and power, the student is faced with other questions and problems. If from an increased understanding of the mechanisms of inheritance we gain the ability to affect inheritance, how should that ability be used? Would a reduction in the variability of species be economically or aesthetically advantageous? Does the analysis give different answers if we look at long-term as well as short-term consequences? Have we gained a better understanding of inheritance through the science of genetics, or have we reduced our idea of inheritance to what can be explained mechanistically -- or have both occurred? This teaching of Mendel's work is heuristic in two ways: a problem that has been made genuine for students is brought nearer to solution by the use of a series of heuristic devices common in science -- the search for a mechanism, redefinition in terms of the mechanism, the use of a discovered mechanism as an "ideal of natural order" -- and the achievement of a partial solution becomes the occasion for facing new problems or redefined older problems.

The whole of science is, of course, a heuristic enterprise. The achievements of science -- its laws, models, and theories -- are "unproved or incapable of proof" in any rigorous sense of "proof." Thus, an analysis of discovery in science may suggest heuristics that will be valuable in science teaching.

Any "discovery" in science has two aspects: (a) the uncovering of something -- an idea, a technique, a fact -- that seems relevant to the solution of a problem in science, and (b) the testing of that something to determine whether it is helpful in attacking the problem, whether it should be counted as a discovery. The second aspect is stressed most in philosophies of science since the knowledge claims of science rest on the adequacy of the procedures used to assess any purported bit of "new knowledge."

The critical aspect of science, the policy of subjecting selected hypotheses to a program of active doubt until the hypotheses are sufficiently justified -- these should be taught as part of the heuristic of science. Students should from time to time be confronted with the problem of the adequacy of justification for particular elements of the corpus of science: What quantity and variety of evidence would be required for an "adequate" justification? What action on our part follows from a judgment that justification has been adequate; what is the justification adequate for?

There can be no heuristic teaching without problems, but there must also be successful solutions to some of the problems if the teaching is to be heuristic. Students, like scientists, must learn when to count their work in science a success. If their standards are too low, they will leave their problems too quickly; if their standards are too high, they waste time in needless buttressing of already acceptable work.

Learning the standards of public criticism is an important part of learning the heuristics of science, but it is clearly only a part. How do scientists go about generating ideas that may deserve a critical test? The process by which scientisits recognize significant problems and generate fruitful hypotheses is not algorithmic. But while it relies on an unspecifiable artistry and taste, the process does have more form than Bridgman's "doing one's damndest with one's mind, no holds barred"[5] would suggest.

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[5] P. W., Bridgman, "Prospect for Intelligence," in Reflections of a Physicist. (New York: Philosophical Library, 1950), p. 342.

For an individual scientist, inquiry is a continuing interplay between his expectations of phenomena and his (and others') observations of phenomena. Observations, of course, are not made without expertise and intellectual effort. An investigator will behave in one way when he believes his observations to be trustworthy and in another way when he does not. Consider, for example, the oft-quoted cases of Fleming's observation of a zone of inhibition around a growth of penicillium and Roentgen's observation of fogged photographic plates. Other investigators had seen similar phenomena in similar circumstances[6] but weren't "prepared" to make the discovery. What was lacking in their preparation? An inquisitiveness, perhaps, but more likely it was confidence that the phenomenon seen could be reliably replicated. If a scientist is not especially careful, his experiments will be dogged by a considerable "background" of random events, and he is likely to pass off unanticipated (and potentially interesting) events as mere "noise." Only the scientist who is confident of his observational and experimental skills and care can be sure of a stable background against which events may stand out as discrepant.

Observation and Experiment

A warranted confidence in one's experimental ability is heuristic, but high school science students are rarely given the opportunity to develop their observational and experimental techniques to the point where they can be used with confidence. Students in laboratories are almost never provoked to "clean up" their initially messy data and to perfect their technique to the point where the trend of the data is unmistakable. Instead, data which are at best suggestive are taken as solid evidence for the "fact" or "law" that the teacher had in mind. The dishonesty of this practice and the sloppiness engendered in students are antiheuristic.

Mastering existing techniques and strategies is not the only way scientists arrive at accurate and revealing observations. First attempts to observe a new set of phenomena may suggest the existence of a pattern that can only be made clear by modifications of existing procedures, by the measurement and removal (often by calculation) of unwanted effects, or by devising completely new observational or experimental techniques. Development of these novelties in technique is often related to conceptual advancement; conceptual and theoretical treatments of phenomena may become clarified in the attempts to develop new techniques or instruments, and advances in instrumentation are the consequence of both practical and theoretical inventiveness. The phenomena made available for study by new techniques and instruments often stimulate new bursts of theoretical activity. Thus, the invention and extension of technique is a heuristic activity in science.

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[6] W. I. B. Beveridge, The Act of Scientific Investigation (New York: Random House Vintage, 1957), p. 47.

Because of our predilection for demonstrations in science teaching, students are rarely given the opportunity to devise or modify techniques that would make clearer the pattern of phenomena. Too often, students make their first (and only) observational contact with phenomena that have been superclarified by an instrument like an Atwood machine, or by a well-developed technique like biological staining. Where this is not the case, as in some of the laboratories of the new science curricula, students are not provoked or given time to develop refined or novel procedures that will improve their initial observations. In either case students are given little chance to develop either the disposition or the analytic skills necessary for the improvement of observational and experimental technique. The heuristic aspects of such an improvement are never brought to view.

Observation is essential to science, but what we choose to observe is colored by our expectations of phenomena. The sources of those expectations, what Toulmin in an apt phrase calls "ideals of natural order,"[7] characterize a science at least as much as its observational base. When we describe a science we usually talk mainly of these ideals of natural order and of their formal counterparts -- laws, models, and theories. Thus, these conceptual elements are central in science. How do they figure in scientific inquiry?

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[7] S. Toulmin, Foresight and Understanding (New York: Harper Torchbooks, 1963), Chapters 3-4.

In much of scientific inquiry the existing conceptual framework is used as a guide for making sense of new phenomena. Much of what is newly observed can be fitted, with relative ease, to parts of the conceptual framework then in use; the remainder, the "anomalies," are taken as the focus of investigation. Attempts are then made to "fit" these anomalies. One form of the attempt is an analysis to see if the "anomalies" are truly anomalous, or if they are simply experimental and observational errors or effects that can be explained by reference to other parts of the conceptual apparatus. A second form of the attempt is minor adjustment of the conceptual apparatus in search of a better fit. This is usually accomplished by redefinition of concepts, or the introduction of new minor postulates consistent with existing ideas about the nature of the phenomena. Each is an attempt to "patch up" the existing conceptual framework so that it will handle new cases. Finally, the anomalies may prompt a radical critique of existing concepts and a thoroughgoing search for a new ideal of natural order to cover both the new and the old, the currently explained and unexplained phenomena.

When ideals of natural order and formal theoretic elements are used with some confidence, they function as problem-finding heuristics, identifying the observational anomalies that will become problems for science. They are also used for the solution of these problems. But the conceptual framework of science may itself be the subject of inquiry. This is most noticeable and widespread when anomalies persist and accumulate, but conceptual critiques and the trial of new "ideals of natural order" may also be pressed by individuals who have no observational stimulus. Aesthetic criteria or even the romance of being "a seer" (and the acclaim it might bring) may prompt a reexamination of basic assumptions and presumptions.

Thinking Tools

In the application or critique of the existing conceptual framework scientists make recurrent use of some "moves" that may function as heuristics. For example, Shockley has listed his "search-thinking tools."[8] These

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[8] These are discussed and illustrated in W. A. Shockley and W. A. Gong, Mechanics (Columbus, O.: Charles E. Merrill, 1966).

"tools" include "simplest cases," "pencil-paper," symbols, diagrams," "one-to-one correspondence, analogies," "idealized limiting cases," and "conceptual experiments." The probable utility of each "tool" will differ with the circumstances. Thus, when faced with a new situation or with novel phenomena, a scientist will probably try to highlight essential features and to schematize the phenomena by the investigation of "simplest cases," and the use of "pencil and paper" and of "symbols and diagrams." The development of "one-to-one correspondence and analogies" may be useful in relating the phenomena under study to trusted conceptions, or, when existing conceptions are in doubt, in the search for promising models from other fields. When the existing conceptual framework seems inadequate, "idealized limiting cases" may be explored and "conceptual experiments" tried in hope of identifying the location and form of the inadequacy and, thus, learning where to focus attention.

If Shockley's list is compared with existing classroom practice, it becomes obvious that many of these heuristic moves are already present but are not used as elements in an inquiry. Analogies, diagrams, simplest cases are commonly used in the didactic presentation of "what is known." Analogies are used to "make reasonable" belief in a principle or model that will not be adequately justified in its own terms. The correct use of symbols and diagrams, often it seems for their own sake, is a common objective in science teaching. Simplest cases are explained as if they represented whole sets of phenomena, sets that are never examined and often not mentioned. Instead of being tools to be used in the search for the solution to problems, these "moves" are used to permit an economical display of problem solutions already in hand.

One major problem for heuristic science teaching is the sense of teachers that significant problems have been solved and that it would be dishonest to pretend otherwise. To the extent that science teaching is a recapitulation of the achievements of science the impulse to display achieved solutions will be in conflict with the teaching of heuristics. At best (and it is not a poor best) the heuristics used by the original discoverer will be reviewed by the teacher and, perhaps, practiced by the student.

There may be some sense of drama, of choices available and made with consequence, but it will be a drama whose story line is well established.

The basic difficulty cannot be avoided in a science teaching which is wholely a recapitulation. But the phenomena dealt with in science teaching need not be only those that are of special interest within scientific systems. There are any number of phenomena that are not "standard fare" and that may be of interest to students (and teachers) because they are commonly encountered. How does a child make a swing operate? What happens to a flashlight battery when it runs down? How do birds "learn" their songs? Does a baby "recognize" its mother? Attempts to answer questions like these would bring heuristic devices into play as heuristics. These attempts might convince students that science is neither programmable or random behavior but is instead a sensible and artful use of existing knowledge and technique in hope of becoming more knowledgeable.

An approach to science that is wholely within science may divert attention from the heuristics that may be most useful to the student as a citizen. A scientist is concerned with extending and deepening his understanding of phenomena, especially those phenomena that have most direct bearing on the fundamentals of his conceptual apparatus. The citizen, though, is concerned with action and choices of action. He seeks an understanding of the phenomena that will affect and will be affected by his potential courses of action. His interest is not in the phenomena per se, but in the phenomena as they are related to what he may do. A "deeper" understanding that does not inform his choices would not be helpful and might even be harmful, especially if it diverted attention from the exploration of other controllable aspects of his choices. Students might find it very useful to learn how to bring scientific expertise to bear on a practical decision. Not only must the reliability of the information and principles made available be assessed, but decisions must be made as to how much and how detailed the input from science need be, and also means must be worked out for translating from the practical frame of reference to the scientific frame and back again. For some practical problems science is a source of values, as well as information. The student will have to assess the values proposed by scientists as well as the information secured from them. In dealing with practical problems, the heuristics of deliberation[9] are learned. To the extent that deliberative heuristics need to be adapted to the content and processes of science, they cannot be adequately taught in, say, the social studies. Some consideration of practical problems and the role of science in practical decision making will have to occur in the science classroom.

Much of what has been suggested to this point is concerned with science teaching that is heuristic for students. What will make science teaching heuristic for teachers? Some of the suggestions already made apply equally well to teachers, for they can never exhaust the occasions for explanation of "common" phenomena and, in a changing society, will ever be learning newly appropriate heuristics of deliberation. The questions arising from science cannot be "solved"; they can only be addressed more or less well. But what will be heuristic for the science teacher as a teacher? How can he learn to solve the problems of science teaching?

To answer these questions is, in some respects, to enumerate the problems of science teaching. But the list is too long; attention must be focused on what is central. The central problem in heuristic science teaching is the appropriate channeling of resources to a real problem. What will be "appropriate?" We cannot give a clear answer; if we could, the process could be mechanized. We can, however, acknowledge some conditions to be met. For example, Polanyi suggests that "the choice of a problem must not only anticipate something that is hidden and yet not inaccessible, but also assess the investigator's own ability (and those of his collaborators) against the anticipated hardness of the task and make a reasonable guess as to whether the hoped for solution will be worth its price."[10] The teacher will inevitably have a strong hand in selecting and structuring the problems to be addressed. He must, therefore, be able to make a reason ably accurate assessment of his students' abilities. What conceptual apparatus do the students bring to the task? How many heuristics of inquiry or of deliberation can they effectively use? The teacher can answer questions like these only by bringing his students to face a real problem, by helping them to articulate their conception of the problem and of the resources that can be brought to bear on it, and by monitoring and guiding their attempts to solve the problem. The heuristics that guide the teacher -- questions of clarification, attentive observation of student actions, hypotheses about students' "ideals of natural order" -- are counterparts to the heuristics of scientific inquiry. Like their counterparts, they function as heuristics only if used in a context of inquiry. For the problem of assessing student capability, at least, science teaching can be heuristic for the teacher only if it is heuristic for the student.

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[9] This is suggested by Joseph Schwab's use of the same term in "The Practical: A Language for Curriculum," School Review, 78 (1969), 1-23.

[10] M. Polanyi, Personal Knowledge, p. 124.

THE HEURISTIC TEACHING OF THE VISUAL ARTS

Elliot W. Eisner
Stanford University

This paper will describe four aspects of the teaching of art that relate to the role of heuristic teaching in that field. First, it will identify the function that term has performed in the field. Second, it will describe the general set of assumptions that have been employed in the field of art education over the past three or four decades that relate to the concept of heuristic teaching. Third, it will describe some of the characterisitics of the "well-run art class." Finally, it will present a pair of theoretical models that relate to heuristic teaching as an image or vision of what teaching should be.

First, it must be realized at the outset that the concept of a heuristic, whether in teaching or in other aspects of educational practice, has not had a history in the literature of the field of art education. I suspect that most teachers who are now working in elementary or secondary schools teaching art have little idea of what the term means. Furthermore, I don't believe this situation to be unique: I suspect that teachers in all of the fields which now occupy a place in school curricula would have similar difficulties. One might even go further to suggest that the concept is not well understood or used with currency in university schools and departments of education. Thus, the concept that we are dealing with in this paper -- as a formal concept having technical meaning -- is new.

If one uses the general definition that is provided in the materials prepared by Professor Snow[1] as a general descriptive definition of heuristic teaching, namely that:

> Heuristic teaching refers to styles of teaching which emphasize the development of self-initiated and self-directed pupil learning; which stress the pupils' discovering rather than absorbing knowledge;

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[1] See introduction.

> which places the student in the role of inquirer; which aim at heightening the relevance of school to the pupils' life; which are concerned with the emotional and social development of the pupil as well as with his cognitive growth,

then practices along these lines in the teaching of art at both the elementary and secondary school level have had a substantial history. This history is based upon the kinds of intellectual and normative affiliations that members of the field of art education have long had. These affiliations have been based upon the general spirit underlying progressive education as it developed from the turn of the century as well as upon the work that was done by G. Stanley Hall during the late 1880's. What were the major ideas in these movements? How did they develop in the field of art education? What kinds of assumptions and teaching practices did they lead to?

The general orientation that was advanced by Hall, supported in part by John Dewey, and developed with force during the 1920's was one which viewed the child as an unfolding organism that needed opportunity to develop those potentialities, capabilities, and interests that he possessed. The tack that Hall took in his thinking about the child was one of viewing him as an organism that somehow in the course of his own development recapitulated the development of the human race. For Hall the mind of the child was qualitatively different from that of an adult and needed to be respected by the teacher in the classroom. Hall's interest in the development of the child's mind, in the covert potentialities that he possessed, and in his natural development was in part supported by Dewey, who utilized some of these conceptions, as well as those advanced by Darwin, in developing a commitment to the fostering of human intelligence as the primary goal of education. To do this it was extremely important for the teacher to work with the child and to develop jointly those programs and projects that would present him with situations that were problematic in character. From the sense of the problematic the child was to develop those competencies in speculation, data collection, and analysis that would enable him to bring the problem to resolution and thus to restore his equilibrium.

The reasons for laying this background for my discussion of art teaching is because it has been extremely important in shaping the character of the field of art education.

Art as an Instrument for Growth

Art educators over the past three decades have been genuinely concerned with the emotional and intellectual well-being of the child. They have also displayed a profound interest in fostering the child's creative development. For years the major thrust of the field has been aimed at utilizing art activities as a vehicle for the general creative development of the child. One of the most influential books in the field of art education, first published in 1946 and printed in seven languages since that time, is Viktor Lowenfeld's Creative and Mental Growth. The major orientation of this book is to use art as a vehicle for "creative and mental growth." Another book, equally as influential, was written by Sir Herbert Read, an eminent English critic, poet, and philosopher. The title of his book is Education Through Art. Note that in both titles -- and in their contents -- the visual arts are considered instrumentalities useful for attaining more generalized educational ends.

What we have had then over the past 30 or 40 years in the teaching of art in the United States, at least in the literature and in many cases in practice at both elementary and secondary levels, is a series of ideas which emphasize the importance of enabling youngsters to generate their own ideas in the classroom, which encourages them to use visual media as vehicles for expressing these ideas and feelings, and which recognizes that the creation of visual art is not merely a product removed from the child's affect or personality but is an extension of himself.

The type of didacticism, meaningless verbal learning, and rote method that has typified many elementary and secondary classrooms in this country at large has not been a characteristic problem in the teaching of the visual arts. Although there are some classroom teachers who have used and who still use dittoed materials to be colored in, these practices have, in my opinion, existed only in small proportion to practices which are extremely more liberal in character. Thus, the general philosophical orientation that has permeated the field, an orientation growing out of the child study and progressive education movement, has militated against the kinds of instructional practices that heuristic teaching as a teaching style is trying to ameliorate.

These beliefs, this vision of the child and his education through art, have also militated against the expectation of having a standard behavioral output through a standard teaching input. In fields that emphasize verbal discourse as the major means of communication there has been a tendency to expect common terminal behavior at the end of an instructional sequence. The teacher who, for example, is teaching spelling, mathematics, or even social studies, might expect a common set of the students would get 100 on their performance in spelling and mathematics, and they would all come up with the correct set of answers in responding to questions on a social studies examination. Contrast this with expectations in the teaching of art. The last thing that teachers want in this field is identical performance across students. What is sought is heterogeneity of response; variance is what is desired. In the discursively oriented fields, homogeneity of response is often desired. Indeed, a perfect teaching performance to a group of youngsters by definition leads them to the achievement of certain previously defined ends. Where these ends are common across students -- as they often are in practice -- the teacher hopes to achieve a group response that has no standard deviation.

Thus, one of the significant differences in expectation concerning performance in the teaching of art compared to most of the other fields is the desire for diversity of performance and, associated with such a desire, the realization that prediction of the characteristics of such performance will not be great.

Given these assumptions, assumptions emanating from a set of intellectual and social historical conditions, what kinds of practices are now being employed in the teaching of art that relate to the definition of heuristic teaching quoted earlier?

Art Teaching Is Heuristic

First, let me say that the well-run art class would match both in spirit and in practice the components identified in the definition that has been provided. In the teaching of art this would mean providing opportunities for students to select from an array of projects those projects with which they wanted to work. Thus, it would not be unusual to find art classrooms in which four to seven different projects were occurring at the same time. Some students would be working in problems in clay, others would be painting, a third group might be doing metal work, the fourth group might be exploring graphic techniques. The general character of the classroom therefore would be one in which there was a hum of activity and a fair degree of physical mobility. As students needed certain types of material to work with on their project they would feel free to move around the classroom in order to find materials and to bring them back to the place at which they were working. The role of the teacher in such a setting would be much more like a consultant than a person standing in the front of the room lecturing to a group of children. The teacher would be moving about from youngster to youngster, from group to group. Conversations with the students would deal with any number of issues: it might deal with the general aesthetic character of the work that was being created, it might deal with the problems that the youngster might deal with encouraging the child to think more imaginatively about the work that he is now doing, it might be offering some emotional support to a child who is hypercritical about the quality of his own work. These and a host of other possible tasks would be undertaken by the sensitive teacher as he moves around the classroom working with the students individually or in small groups. An important goal of his activity would be aimed at developing the child's ability to perceive the qualities that emerge from his ongoing activity and to think imaginatively and independently about them. The major mission of the teacher would be to facilitate the students' independence and initiative which, incidentally, is often measured by the length of time and sense of engagement the students displayed in their work.

Where critical analyses of the student's work are done well -- and this is an area in which even the best of art teachers often need help -- it consists of viewing the student's work with the student as a joint critical venture. The task of the teacher in such a setting is not primarily one of applying a standard to the work but to talk with the youngster about his work in such a way that he perceives those subtle qualities that he would not normally perceive without the teacher's help.

In short, when criticism is handled well in the classroom the teacher functions as a critic who sees his mission as opening up the work to the child by providing verbal-visual cues that enlarge his perception of his own efforts. Where a child needs emotional support and approval these are provided. The assignment of grades to students is generally frowned upon by teachers of art for all of the reasons that are associated with grading and competition generally.

The motivational practices that are used in the well-run art room often consist of providing students with a series of "experiences." Such experiences might consist of the viewing of an imaginative color film, it might consist of role-playing or psychodrama designed to generate students' imaginative imagery as a prelude to their own creative work, it might deal with a field trip or with the demonstration of a new technique that is likely to have some impact on the student's imagination. The major idea underlying such motivational practices is to provide a springboard that the student can use in his own creative work.

Two Theoretical Models

Although the ideas underlying such practices have stemmed from general notions related to the child study movement, experimental philosophy and progressive education, the systematic theoretical analysis of these notions has not been well articulated by members of the field of art education. There are two theoretical models relating to cognition that might be helpful in clarifying thinking about the demands that heuristic teaching make upon the student. One model is called a sequential processing model, the other a multiple processing model.

The sequential processing model envisions the student in a situation where limited and well-defined stimuli are presented and to which he is to learn to respond appropriately. In such a situation the environment is sometimes artificially constrained so that focal attention is increased. The teacher's problem in such a situation is to provide a series of such stimuli, one after the other, that will link together to form a chain which will terminate in the student's ability to perform a complex cognitive operation or behavior. Perhaps the most acute and clear-cut model of such a situation is the linear program as it is employed at the computer terminal. Note that when the student is at the terminal his peripheral vision is cut off by the wooden enclosure in which he sits. Furthermore, his ears are covered by ear phones that are used to communicate with him. His vision is directed toward a cathode ray tube which is approximately 12 to 18 inches away and a keyboard and light pen which he can use is made available.

The programmer -- who is the teacher in such a situation -- is concerned with providing the appropriate links in order for the chain to grow. The need for each link or frame to link up to the preceding one is crucial since the stimuli to which the youngster can respond has been so limited. If a frame or link is missed, the dependent links or frames that are to come cannot be connected. Thus with a highly structured and delimited set of stimuli the need for precision in the sequence among links is essential. Such a program provides very little scope for the development of alternative linkages since the resources for new combinations are not available.

Now compare that model with a multiple processing model. In the latter model the problem of instruction is seen as providing the student with a wide variety of diversified stimuli from which he may select in order to construct a particular cognitive structure or personal meaning. The problem that the teacher has is primarily one of deciding upon the environmental conditions, especially the core set of stimuli, that will generate interest, enthusiasm, and a sense of possibility among students. The set of assumptions that the teacher works with is one which rests upon the notion that when children are given a rich and diversified environment they will themselves be in a position to take out of that environment those aspects that they consider useful or meaningful. Using the analogue of the links and chains, what the teacher is doing in a multiple processing situation is one of providing a wide array of diversified links which are not hooked together. He expects that the children will select those links among the group that seem "hookable." Furthermore, he assumes that once these links are selected the problem that the student will have is one of inventing ways of hooking them together. In such a situation, he does not expect all of the students to select the same links nor does he anticipate that their method of linkage will be identical. Indeed, he anticipates that students will pull out of the situation what is relevant to them and that the virtue of such a situation is based upon increasing the probability that they will make personal meaning in the act of construction.

In such a situation the teacher worries little about sequence between projects. Since movement from one project to another occurs by the provision of different sets of links he assumes that children will hook up between projects those connections that they can see. He might facilitate this by making suggestions to individual pupils or to groups of pupils, but he is not at all interested in their moving simultaneously along a single line.

It is interesting to note that much of what is going on in the more progressive English primary schools, especially in northern England, is related to the distinctions I have just drawn. While the English do not tend to make such distinctions in their thinking about educational practice (they tend not to be very theoretical about what they do) their practices reflect the differences the distinctions imply. Indeed, the kinds of concerns that we have for systematic instruction, sequence, and the attainment of specific behaviorally defined goals are precisely the kinds of things about which they have little interest.

In summary, the general characteristics of heuristic teaching as it has been described in the material that was sent to me is consonant with the general spirit of teaching in the field of art education as it has developed over the past 30 or 40 years. The reasons for an art teacher's sympathy to such orientation have already been described in terms of their historical antecedents. The characteristics of the well-run art class have also been described. The most general set of characteristics of such classrooms are those in which the teacher tends to encourage students to identify projects out of an array of projects that they would like to undertake, to feel free to move about the classroom to use the tools and resources necessary for working on such a project, and a general concern by the teacher for the youngsters' sense of personal worth and accomplishment. These characteristics are not rare among teachers of art and, unless I am biased, probably more prevalent than one is likely to find among teachers of other fields for the variety of reasons indicated.

The general tone of my remarks in this paper have had a positive character to them with respect to the usefulness of heuristic teaching in the schools. In general, I am quite sympathetic with such an approach in the educational process. However, there are situations in the school where systematic instruction, indeed, sequential cognitive processing, is extremely appropriate. I believe one of the pitfalls that should be avoided in the study of teaching is that of falling into the use of a set of norms concerning the teacher's and student's role that is not qualified by the purposes and context in which those roles are to be performed.

HEURISTIC TEACHING IN THE SOCIAL STUDIES

Jan L. Tucker
Stanford University

The concept of heuristic teaching has neither a lengthy history nor great currency in social studies education. However, as it is described in the literature of the Stanford Center for Research and Development in Teaching, heuristic teaching appears to be quite similar to the notion of inquiry teaching, a term that has become very closely identified with the so-called "new" social studies.

The literature of the "new" social studies is replete with commentary agreeing with the R&D Center's urging that "a substantial portion of educational effort should be devoted to developing individuals who are adaptive, flexible, and inventive"; that didactic teaching is inadequate to the task; that we need a kind of teaching which promotes "the spirit and mood of inquiry, critical skepticism, invention, imagination, and enthusiasm for learning"; that the teacher should be an "active inquirer," should stress "openness of inquiry," and should appeal "to the authority of free inquiry rather than to the authority of persons"; that the student should be an "active inquirer rather than a passive recipient of knowledge" and should "assume responsibility for his learning"; and finally that inquiry teaching both requires and fosters an "open" school and classroom climate.

Thus, while the term heuristic teaching is not well-known in the social studies, the characteristics ascribed to it by observers outside the field tend to make it coterminous with the more popular concept of inquiry teaching in the social studies. This suggests that it will be productive to examine the nature of inquiry as it is used in the social studies, and analyze what this inquiry means in terms of inquiry teaching.

The major thesis of this essay is that any productive understanding of inquiry teaching (read heuristic teaching) in the social studies must take into serious account the fundamental confusion and disagreement regarding the meaning and purpose of social studies education as it exists today. To ask the question -- what is inquiry teaching in the social studies? -- forces one to ask the prior question: what is (are?) the social studies? Answers to this question should help in the formulation of the right questions to ask about the subject of this essay, the meaning of heuristic teaching in the social studies.

At the outset we will find it useful to develop an abstract, ideal meaning of heuristic teaching in the social studies. But to conclude at that point would leave us elegantly removed from the reality of contemporary social studies education. I intend to move us closer to the conceptual noise and value contention by attending in some detail to emerging paradigms in social studies education. I will argue that the particular paradigm preference of any given social studies educator is likely to have a great influence on what he can accept as an appropriate set of heuristic teaching behaviors.

The remainder of this paper will be divided into two parts. The first part comprises a brief description of an ideal heuristic type in social studies education. The more detailed second part is a discussion of emerging curricular paradigms in social studies education. These paradigms will be differentiated according to preferences with respect to problem types (content) and inquiry styles (process). The implications of these paradigms for heuristic teaching will be examined by comparing the characteristics of the ideal type with each paradigm. For example, the concept of an "open" learning situation as a necessary heuristic condition will be used to illustrate differences among the paradigms.

An Ideal Heuristic Type

What behaviors does one look for in a heuristic social studies situation? Heuristic social studies education is characterized by a seeking, questing, searching attitude. There is an air of excitement engendered by confrontations with indeterminate, problematic situations. Process is viewed as being as important as content; knowing becomes as important as knowledge. Problem finding and divergent thinking are valued equally with problem solving and convergent thinking. Activity is sometimes structured, sometimes systematic; in any event, activity is purposive and defensible in terms that can be articulated by both teachers and students and can be understood by reasonable people.

Learners in a heuristic situation are interested, absorbed, alive, and curious. They value warranted knowledge and they actively embrace relationships and behavior styles which enhance human dignity. They are critical, yet productive. It is second nature for them to function in the role of participant-observer. Consequently, they are skeptical, yet they can comfortably take part in the celebrations of their culture when they feel these celebrations contribute to human dignity.

What educational conditions are probably necessary to achieve the heuristic ideal? The teacher must be secure enough to examine and question some of the "sacred cows" of social studies theory and practice such as the traditional authoritative role of "facts" and textbooks. He must himself be a model of inquiry; he can do this by being consistent and intellectually honest with the students; by providing ample opportunity for students to demonstrate their developing analytic powers and interpersonal skills; by letting them make mistakes and work their way out of these mistakes; by admitting to not knowing all; by being a part of the inquiry, not apart from it; and by being willing to take some personal and intellectual risks thereby demonstrating in appropriate instances that he is committed to a rational, consistent value system.

This teacher regards himself as more than neutral purveyor of established knowledge, more than a transmission belt between the society and the learner, more than a highly trained technician. He considers himself to be a choicemaker who can make an important difference in the lives of students. He is both idealistic and tough minded. His modus operandi is one of responsible subversion when it comes to unexamined, conventional wisdom.

The learning situation is an "open" social system. By "open" it is meant that leadership and authoritative roles shift according to the group's perception of the demands of the situation and the nature of the problem under discussion. Everyone is assumed to be knowledgeable about something of mutual significance; it is assumed that all can learn from each and each from all. The heuristic teacher looks for this individual knowledge and orchestrates the learning activity so that it may be included into the deliberations of the group. Ideally, the teacher's role as director of activities eventually blurs over into one of participant in activities.

Interpersonal conflict is recognized as being a social reality and is dealt with, not avoided or repressed. The learners develop equal respect for the affective and cognitive expressions of human relationships. Mainly it is a climate that permits learners to deal sensitively with those things that make human beings human; the climate contains a delicate configuration of thinking, compassion, productivity, humor, variety, performance, growth, and competence.

Emerging Paradigms in Social Studies Education[1]

The social studies, as most other subject-matter areas, can look back upon a decade of ferment. However, if the total impulse for educational change during this period can be roughly differentiated by the metaphors of boundary--pushing vs. boundary-breaking, there is little doubt that most of this social studies reform can be most comfortably characterized as boundary-pushing. That is, social studies ferment has been guided by the norm that formal education needs to be changed; but this can be better accomplished by improving upon rather than rebuilding the existing structure of public education. Despite some overtures to the contrary, the so-called "new" social studies does not directly challenge fundamental assumptions about the organization and purpose of public education. It is with some admitted reluctance that I have chosen to limit this analysis of heuristic teaching to the boundary-pushing context, the context commonly referred to as the "new" social studies. The essay on boundary-breaking social studies remains on hastily written and widely scattered notes. In any event, such a statement at the current time could at the most serve as a heuristic device itself; for even the more conservative boundary-pushing social studies is having some trouble penetrating into American schools.

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[1] This use of the paradigm concept as applied to curricular phenomena is drawn from Bridgham's analysis of claims made for science curricula. Broadly construed, a curriculum paradigm is a set of criteria of more or less cohesive value, e.g., about knowledge, knowing, learning, and man's world view, which gives shape and energy to a particular curricular conception. Bridgham suggests that conceptions of science determine the claims made for science education. Inquiry into this relationship is helpful but insufficient for any analysis of the claims made on social studies education for, as will be shown, many curricular claims in the social studies are drawn from sources other than science. Thus, while the paradigm concept as used in this essay is drawn from its meaning in science and science education, it is being applied to curricular phenomena which do not necessarily have their major claims grounded in conceptions of science. This should prove to be no problem if it is remembered that the paradigm concept refers to a "shared world view and the corresponding common definition of a field of study." See R. Bridgham, "Conceptions of Science and Learning Science," School Review, 78 (November 1969), pp. 25-40.

What then are the salient features of the "new" social studies? Warmed by increasing amounts of money, particularly federal money, channeled into public education during the 1960's, the present social studies cauldron contains, among others, three highly significant and dynamic ingredients: (a) emerging conceptions of the nature of a research discipline; (b) fresh thinking about the nature and purpose of inquiry; and (c) efforts to incorporate additional social sciences into the social studies curriculum. Not unlike earlier reform in mathematics and science, it is largely an attempt to translate the rule-governing logic of the subject matter, called the "structure of a discipline," into the dynamics of the teaching-learning process. From a distance one gets the general impression that, indeed, something different and congruent is developing. But upon closer inspection, the "new" social studies is not of one piece. The nearer one draws, the more he gets the sense that the "new" social studies has a multiple rather than a singular character. Previous analysis has revealed not one, but four emerging paradigms in the social studies. These are: (I) the scientific-empirical, discipline-centered; (II) the humanistic-philosophical, discipline-centered; (III) the scientific-empirical, practical problem-centered; and (IV) the humanistic-philosophical, practical problem-centered.[2] Thus the "new" social studies has not one, but at least four major paradigms; not one, but at least four different definitions of the appropriate nature of social studies education. An understanding of this multiplicity is of vital importance to the explication of the meaning of heuristic teaching in the social studies.

At a beginning level, the importance of differentiating among claims made on the social studies is underscored by the relative impact of each paradigm upon social studies thinking and practice. For example, it is generally agreed that most of the ideas for the "new" social studies have been generated by the national materials development projects.[3] And the large majority of the projects exemplify Paradigm I, the scientific-empirical, discipline-centered paradigm. Few of these projects have claimed that new and better materials are the only factor leading toward the improvement of social studies education; but many of them do maintain that materials are the major factor. The net result, at this juncture in the history of the "new" social studies, is that relatively little serious attention has been given to other important factors. Classroom climate as a potentially important variable in heuristic teaching and the characteristics and skills needed by teachers to develop this climate have been given only "footnote" attention by most of the projects. In short, despite some lip service to the contrary, the anatomy of heuristic teaching in the social studies is largely uncharted.

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[2] J. L. Tucker, An Exploratory Classification and Analysis of Selected Problem Areas Within the "New" Social Studies, Unpublished Doctoral Dissertation, Indiana University, 1968.

At a second level, the importance of differentiating among claims is highlighted by the probability that a particular set of heuristic teaching characteristics can be hypothesized as being fully functional and consistent with a particular conception of social studies; but if examined carefully, this same set of heuristic teaching characteristics may be counterproductive when viewed in the light of a different conception. It is to this analysis that we now turn.

Beginning with a schematic overview, each paradigm will be analyzed in order. The scientific-empirical, discipline-centered paradigm is considered first because it is the most pervasive and most fully represents the core of reform over the past decade. The order of presentation of the remaining three paradigms, however, is not based upon any descending order or pervasiveness. The choice is purely arbitrary, with the possible exception that Paradigm IV most corresponds to the author's values. However, the other three are not "straw men" or "foils," they are quite real and viable alternatives.

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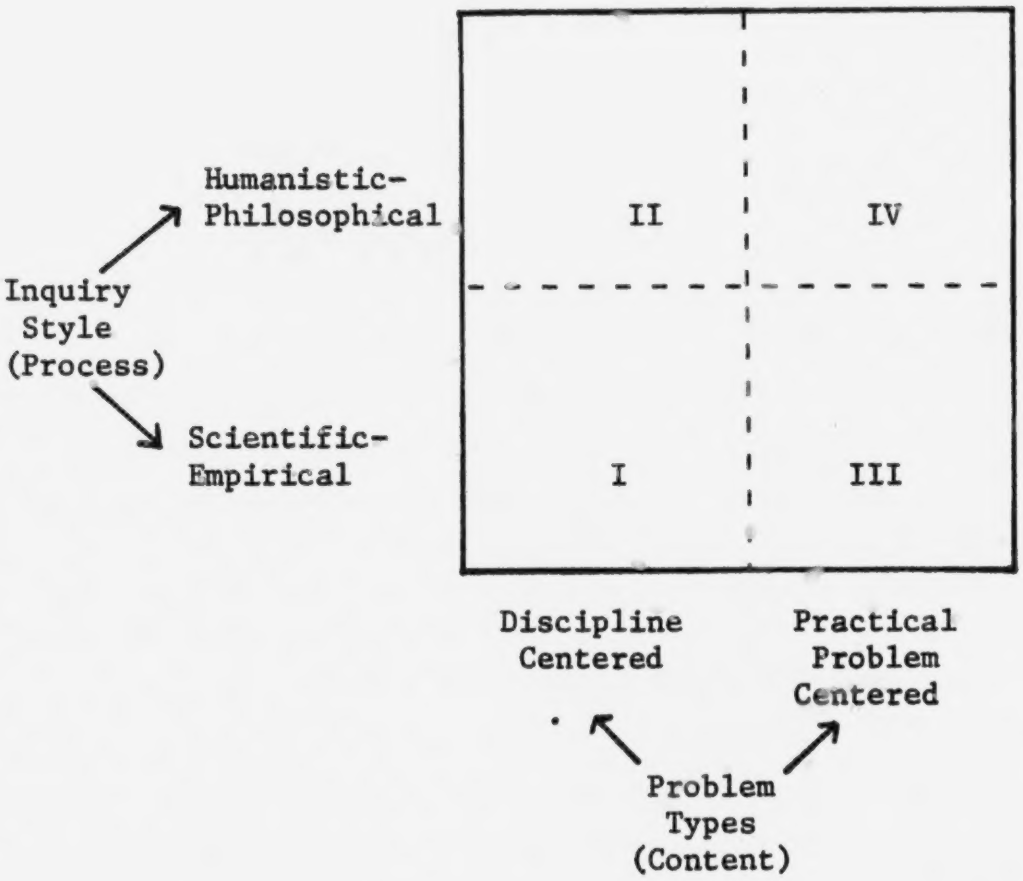
[3] J. L. Tucker, Views of Instructors of Pre-Service Teachers Concerning Emphases Found in the "Professional Discourse" about Recent Developments in Secondary School Social Studies Education, Unpublished Research Report, School of Education, Stanford University, 1970.

A Schematic of Social Studies Paradigms


Humanistic-
Philosophical
Inquiry
Style
(Process)
Scientific-
Empirical
II
IV
I
III
Discipline
Centered
Practical
Problem
Centered
Problem
Types
(Content)

Paradigm I: Scientific-Empirical, Discipline-Centered

Content for the social studies is defined by and selected according to conceptions of social science research disciplines. (The category of social science disciplines as used in this paper is broadly construed to include those disciplines which are generally considered to be social sciences, e.g., economics, plus the more contended ones such as history and geography). Reliable knowledge, in the form of increasingly more powerful conceptualization and more warrantable generalization gained by adhering to the accepted research canons of each discipline, is generally considered to be the end goal.

This paradigm deals primarily with descriptive problems. That is, its inquiry task is pushed forward by asking, "What is the case?" And it yields factual, reliable knowledge about the real world. It is based upon observational or inferential data and is designed to describe, explain, predict, and control; if we do certain things, we are reasonably assured that other things will follow. Consequences in action are suggested, but particular courses of action are not prescribed. Scientific-empirical inquiry emphasizes externality, neutrality, separateness, and order. Its ideal is a world of recurrent entities, each clearly demarcated from every other and combining into more complex structures in regular ways. In reality, science, particularly social science, seldom reaches a fully formalized, deductive level.

The dispassionate search for truth is a paramount value. Facts and causes are more important to scientific-empirical inquiry than values and reasons. This preference tends to set scientific-empirical inquiry apart from humanistic-philosophic inquiry which has decided interests in values and reasons, not only for purposes of description and explanation but more importantly for their function as criteria for selection and appraisal.

The majority of the major materials development projects in the social studies over the past decade, to a greater or lesser degree, have adopted the scientific-empirical, discipline-centered curricular paradigm. The following statements taken from one of the major projects are examples.

> The basic premise of Sociological Resources for Secondary Schools (SRSS) [now called Sociological Resources for the Social Studies] is that the education of today's high-school students can be improved by familiarizing them with the sociological perspective. . . . The sociological perspective . . . is characterized by the effort to construct broad generalizations about social patterns by gathering empirical data through careful and self-conscious techniques that are as unaffected by value judgments as possible.[4]
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> If our goal is reliable knowledge -- knowledge that holds up against rigorous testing -- what means should we use to obtain it? What methods are appropriate? The sociologists' general scheme of inquiry is the scientific method. Using this method, we translate general explanations into specific statements. These statements . . . assert that with a change in one social factor, there

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[4] Sociological Resources for Secondary Schools (Now the Sociological Resources for Social Studies), Designer's Manual, A Project of the American Sociological Association (n.p., 1966), p. 3.

> will be an accompanying change in another. Then we use this statement as a target, testing it under controlled conditions. To do this, the sociologist needs special tools for gathering, ordering, and analyzing the data; guidelines for observation, questionnaires and interview schedules, methods of sampling . . . indexes and ways of measuring things. . . . These are ways in which the sociologist looks at the social world as he seeks increasingly reliable knowledge of what is.[5]

This content derivation decision, whether it results in emphasis on social science content or some alternative such as practical social problems, is guided and appraised by fundamental values about the good society, the good citizen, and the good education. Thus, the decision to derive social studies content from organized social research disciplines signifies the obvious but fundamentally important fact that learning social science is to be the major instructional outcome, a not unimportant value judgment.

The significance of making this distinction about content derivation is underscored by the fact that disciplined knowledge is a preformulated set of rules which is brought to the teaching/learning situation. These rules include the values underlying the paradigm as well as the content and the processes. Naive and untutored in the ways of these rules, students are to be inducted into this particular pattern of rule-governed behavior. The heuristic challenge of this paradigm is for the teacher to find ways of organizing his instruction in such a manner that students "discover," accept, and act in accordance with the rules of social science.

The ideal heuristic teacher for this paradigm is one who can orchestrate the inquiry in such a way that students will be motivated to "discover" this predetermined social science knowledge for themselves. Such a teacher must be a master of a variety of motivational techniques which consistently and persistently prod the student toward a greater grasp of the social sciences. He must have a clear understanding of the lesson objective, a tenacity to stick with the objective, and an ability to ask the probing questions which lead most effectively toward the objective.

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[5] Sociological Resources for the Secondary Schools (Now the Sociological Resources for Social Studies), Hypothesis Testing in the Social Sciences: Teachers Guide, American Sociological Association (n.p., 1967), p. 17.

The learning of social science is not wholly congruent with an open-ended approach to instruction. That is, the social science paradigm requires that the teacher (in many cases it is the "package" and not the teacher) predetermine what knowledge or conclusions the students are supposed to gain from their inquiry. The creation of an open classroom, broadly construed as a classroom where students and teachers are coinquirers, is a perhaps desirable but certainly not a necessary condition of successful instruction. In the final analysis, the values of this paradigm posit the learning of social science as the overriding consideration. If a teacher can accomplish this in an open classroom which entertains issues and approaches suggested by students, then a bonus has been achieved. But given the choice between an open classroom and comparatively low student achievement in social science or a closed, highly teacher-centered classroom and comparatively high student achievement in social science, the latter is clearly the more highly valued.

This paradigm creates conflict for many teachers. The conflict stems from expectations that he teach both social science and stimulate student-generated inquiry. At its core, this tension is framed by means-ends relationships between freedom and discipline. For example, the most avid proponents of the scientific-empirical, discipline-centered paradigm, while valuing both freedom and discipline, would probably argue that freedom follows from an ability to predict and control human behavior, and we can accomplish this only by a willingness to have our conceptual processes and value system molded by the disciplines. The social science perspective is so vital to this end that "force-feeding" the perspective to students is legitimate. Others argue that freedom also precedes discipline and every learner should have the opportunity to decide for himself what perspective on knowledge is most valuable.

Research on teachers' use of subject matter to maintain their authority in the classroom gives us pause to consider seriously whether the total variables at work in the scientific-empirical, discipline-centered classroom tend to tip the scales toward the teacher-centered, closed, authoritarian end of the continum. Consider the following conclusion of a recent review of research:

> The official myth has it that a teacher's principal goal is raising the level of achievement or the quality of thinking of his pupils. However, studies of the perceived problems or concerns of beginning teachers force one to acknowledge a collective secret shared by teachers and all but the youngest pupils alike, that the paramount concerns of the beginning teacher -- and possibly many an experienced teacher too -- focus more on the teacher's own sense of adequacy and his ability to maintain interest and control in the classroom, than on the needs and accomplishments of his pupils. The most straightforward interpretation . . . is that teachers use subject matter to sustain themselves in the role of the principal source of knowledge in the classroom; to evoke interest in what they, as teachers, [or, of course, the projects] have determined that their pupils will do, to justify decisions and evaluations, and generally to maintain control in the classroom. Any presumption of knowledge might be used in this way though it may be that more knowledge gives the teacher more security.[6]

These research implications, coupled with the means-ends conflict arising from the attempt to combine the teaching of social science disciplines with an "open" classroom climate, lead one to speculate that most would settle for the less ambiguous, less threatening, teacher-centered, and perhaps even authoritarian stance. One could expect such a teacher to claim his job is to teach predetermined social science, not to foster an open classroom climate. In the final analysis, an elementary or secondary social studies teacher who bases authority primarily on the scientific-empirical, discipline-centered paradigm may tend to get this authority confused with issues of classroom discipline and control. The unintentional results could well be the emergence of an authoritarian classroom climate, the antithesis of the heuristic ideal.

The salient assumption of the scientific-empirical, discipline-centered paradigm is that the purpose of social studies education is to ensure that students learn the rules of social science, rules which are found in the repositories of the research disciplines. A wide variety of heuristic teaching strategies are theoretically permissible in realizing this goal. However, conflicting expectations about his role in combination with a teacher's security needs may force the practical definition of heuristic teaching within this paradigm into a rather limited teacher-centered and even authoritarian context.

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[6] J. C. Grannis, "The Social Studies Teacher and Research on Teacher Education," Social Education, 34 (March 1970), pp. 293-294.

Paradigm II: Humanistic-Philosophic, Discipline-Centered

The humanistic-philosophic and the scientific-empirical, discipline-centered paradigms are similar in that each seeks to establish, describe, and interpret knowledge about social phenomena. Also, the content for the social studies is derived primarily from organized bodies of knowledge. However, humanistic-philosophic content is more likely to have a wholistic, interdisciplinary cast, and consequently a different inquiry disposition. This inquiry distinction is noted by Arthur Schlesinger, Jr.:

> The mystique of empirical social research . . . leads its acolytes to accept as significant only the questions to which the quantitative magic can provide answers. As an humanist, I am bound to reply that almost all important questions are important precisely because they are not susceptible to quantitative answers. The humanist . . . does not deny the value of the quantitative method. What he denies is that it can handle everything which the humanist must take into account; what he condemns is the assumption that things which quantitative methods can't handle don't matter.[7]

The humanistic-philosophic inquiry disposition assumes that investigation of human phenomena is qualitatively different from inquiry into non-human phenomena; while not rejecting the scientific-empirical style as being a necessary and perhaps sufficient inquiry mode for certain types of problems, the humanist-philosopher argues that it is inadequate, of itself, for all problems.

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[7] "The Limits of Social Science," in E. N. Saveth (Ed.), American History and the Social Sciences (The Free Press, Glencoe, Ill., 1964).

One major difference between the two paradigms lies in the role of values in inquiry. The scientific-empirical paradigm commonly aspires to objectivity by identifying, isolating, and extracting value components from the study. By contrast, the humanist-philosopher controls and objectifies his inquiry by identifying the values, including his own, and incorporates them into the problem identification, understanding, and resolution. The educational impulse of the scientific-empirical mode is to equip learners with the appropriate tools for digging holes; the main thrust of the humanistic-philosophic mode is to provide students with the personal sensitivities and broad-gauged ability to find the most appropriate location for digging the holes.

The fuller meaning of this paradigm begins to take shape. The argument goes something like this. Man's behavior is not bounded by the regularities and uniformities reflected in the assumptions of a social science burdened by a metaphysical determinism. Man is not a prisoner of history and cultural regularities, he is a maker of history and a changer of culture. The empirical scientist often speaks too glibly about regularity, prediction, and control; all stemming from the belief that the world is an object to be manipulated. Humanists do not deny the same need to control human behavior. However, they do deny that the criteria for this control ought to be defined exclusively by a narrowly defined science of mankind; social control also stems from the ethic that men are makers of rules and changers of cultures.

Humanistic-philosophic inquiry is characterized by the compelling effort to ask prior questions. It seeks reliable knowledge about the meaning and significance of problems as well as reliable knowledge within the problem itself. The purpose of inquiry so conceived is to explore the real world, locate those areas where threats to the values of freedom, reason, and human dignity exist, and direct inquiry to these threats. Inquirers so concerned take cognizance of the contributions of the scientific-empirical paradigm, but they also seek other methodologies and other frames or reference.[8]

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[8] The distinctions between the scientific-empirical and the humanistic-philosophic styles of inquiry have been drawn from the writings of such writers as R. D. Archambault, P. Berger, D. Bidney, T. Brameld, A. Edel, C. Frankel, P. Gardiner, E. Johnson, W. T. Jones, A. Kaplan, E. S. Maccia, C. W. Mills, H. J. Muller, B. R. Raup, R. Rudner, J. W. Smith, P. W. Taylor, S. E. Toulmin, and P. Winch.

Paradigm II is a fragmented unsettled aspect of social studies education. It is most accurately characterized by the uneasy belief that the social studies is too readily accepting a value-free, constraining conception of scientific knowing rather than by any definite program integrated around clearly articulated alternatives. It has no developmental base, no cohesive professional group which consistently promotes the values underlying the paradigm. It is the most "emergent" of the four paradigms.

Creativity, divergent-thinking, autonomy, and intuitive insight are key values of this paradigm. By way of example, Theodore Parsons and Fannie Shaftel suggest that singular attention to a rigorous scientific "model,"

> denies the children the kind of questioning, theorizing, reorganizing of data that cultivates autonomy and divergent thinking. The narrow and restricting limits of the approach raise such questions as . . . how much convergence, at what price? . . . could a more open, seemingly more random search for information eventuate in the children pondering their data classifying, inferring, finally designing a model of their own . . . ?[9]

In a similar vein, Byron Massialas writes:

> It should be remembered that the purpose of the social studies enterprise is not only to develop the ability of students to identify dependable generalizations, but to be able to outline steps to be taken, roads to be traveled, utilizing both the cognitive (analytic) and intuitive (creative) processes and skills.[10]

This paradigm seeks the use of ways of knowing not generally acceptable to hard-line proponents of the scientific-empirical paradigm. Manifestations of this preference range from the concept of "participant observer" in humanistic anthropology and sociology to the historical "imaginative reconstruction of the past," the social-psychological concept of "personal knowledge" and beyond. Translated into social studies education, this means greater legitimization for the goal of fostering idiosyncratic, intuitive, divergent, and personal approaches to knowledge. Consider the following statement:

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[9] "Thinking and Inquiry: Some Critical Issues," in J. Fair and F. R. Shaftel (Eds.), Effective Thinking in the Social Studies, Thirty-Seventh Yearbook of the National Council for the Social Studies (Washington, D. C., 1967), p. 163.

[10] "Revising the Social Studies: An Inquiry-Centered Approach," Social Education, 27 (April 1963), p. 187.

> Many of us believe that there are "ways of knowing" not customarily pursued in the academic tradition; non-rational thought such as fantasy "day-dreaming" that stimulates imagination; deep emotional experiences, (love, hate, humor) that communicate meaning on a non-intellectual level; non-verbal skills (craftsmanship, athletic, music) that develop a sense of competence; music or religious experience that helps to clarify ultimate meanings; even nonsensical play may have educational value. But the model of the scholar pursuing truth in his study or his laboratory obscures these dimensions of education.[11]

This comparatively idiosyncratic and situational approach to the acquisition of reliable knowledge is related to our increasingly differentiated meaning of heuristic teaching in the social studies. In contrast to the predetermined nature of knowledge in Paradigm I, establishing the rules of the knowledge game in Paradigm II is part of the classroom inquiry itself. Thus, the ideal heuristic teacher is one who can orchestrate the inquiry so that students assume much responsibility in establishing the rules of inquiry, rules which may vary according to the nature of the problematic situation. Such a teacher must be more than a proficient technician. He must be as knowledgeable about modes for determing ends as he is a master of various teaching techniques designed to achieve these ends. He must know as much about epistemology and the philosophy of social science as he does about teaching techniques and information contained in the social sciences. While such a teacher can be educated, it is highly questionable if he can be trained, at least in the narrow sense that we educators often use the term.

Following from the fact that the rules of the knowledge game are a part of the classroom inquiry and not predetermined, the generation of an open classroom climate becomes an important consideration. Based upon the condition that the rules need to be worked out, that various claims on knowledge and authority need to be negotiated, the teacher and the learner are coinquirers in a very real sense. Thus, an open classroom climate is not simply a desirable heuristic condition, it is a necessary one.

The conception of freedom and authority at work here is that every learner, at some point, should have the opportunity to decide for himself what perspective on knowledge is most valuable. This relieves the freedom/discipline tension seen in our earlier discussion of Paradigm I which is brought on by attempting to teach already determined ends in an open classroom. On the other hand, the ideal heuristic type for the humanistic-philosophical paradigm may be completely unfeasible in most elementary and secondary schools as presently constituted. For example, a teacher who develops such a social studies program is likely to encounter the opposition of many groups including administrators, academicians, colleagues, laymen, and students. It is truly revolutionary to place in question the authority of the organized research disciplines. The only alternative authority is the credibility of the teacher himself, a tenuous reed indeed, given the vulnerability of teachers and public schools.

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[11] F. M. Newmann, "Questioning the Place of Social Science Disciplines in Education," Social Education, 31 (November 1967), p. 596.

Thus, we find tension in this paradigm also. Here it is a conflict between what he sees his role to be and what others see it to be. In the scientific-empirical paradigm, it was more a case of the teacher rather helplessly caught up in the illogicalities engendered by the developmental proponents of the paradigm. Both are dilemmas, but the humanistic-philosophical dilemma is more abrasive, less easy to avoid, and more immediately visible. Such a teacher has few places to hide. On the other hand, the tension created by the scientific-empirical paradigm can be rationalized and disguised. Only the teacher need know the frustration; pressed, he can defer to the projects or to the research disciplines where the authority is based.

The research conclusions discussed earlier can only lead to pessimism with respect to the humanistic-philosophic paradigm. The fact that most teachers are so concerned with maintaining their authority in the classroom, even to the extent of using their subject-matter competence to enforce that authority coercively, represents the antithesis of the disposition needed by teachers to function in a humanistic-philosophic manner.

Another piece of recent research is disturbingly pertinent to the concept of the open classroom. Utilizing attributes of the political socialization concept such as cynicism, citizenship duty, efficacy, and participation, Ehman found that for blacks, more social studies classes combined with an open climate served to increase political cynicism and reduce political efficacy; whereas for whites the reverse relationships held true. He speculated that when blacks encounter the real world in open social studies classes, and when they consequently find they are being ignored or treated unfairly by the system, they tend to become less socialized.[12]

This is not surprising information, but it raises some extremely important and perplexing questions about the unexamined assumption, underlying the whole of recent social studies reform, that accurate knowledge about the real world is ipso facto a "good" thing. We desperately need more information about the relationship of social science knowledge and open inquiry to social behavior and other social phenomena such as social class, cultural differences, loyalties, etc.

In a similar vein, one of the widely recognized yet just as widely ignored factors influencing the "new" social studies is a middle-class bias. This bias is not so much a lack of multicultural perspectives in the materials; rather it is a case of ignoring the influence of social class as it pervades the educational context in which the "new" social studies is implemented. For example, it is probably the case that the "new" social studies has been received most eagerly in predominantly white, suburban schools. If this be true, then it is undoubtedly a product of many variables. We need differentiated information on these variables.

The point is labored because it underscores the necessity of viewing heuristic teaching, at least in the social studies, in the light of systems which include but go beyond the classroom. Heuristic teaching in the social studies may be as much related to social and cultural phenomena as it is to the psychological anatomy of the classroom. Said in another way, the heuristic classroom function in the social studies should be studied, mediated, and appraised in the light of the larger cultural system.

The major distinction between Paradigms I and II is that the former prefers a scientific-empirical approach to knowledge and the latter has more affinity for a humanistic-philosophical style. The humanistic-philosophic paradigm is far less pervasive in the social studies. Having no project base, it is scattered and fragmented. The development of an open classroom climate is a necessary condition because teachers and students are necessarily coinquirers into problems that have no immediately visible authoritative answers. Role tension exists at a level which makes the teacher quite vulnerable. Given the generally conservative nature of the school as an institution, the available research casts the feasibility of heuristic teaching within this paradigm into some doubt. Moreover, recent research on the relationship between an open social studies classroom and certain minority groups raises disturbing questions about some of the major heuristic teaching assumptions of the "new" social studies, regardless of the particular paradigm. More research is needed with respect to the relationship between the heuristic teaching characteristics required by this paradigm and other important cultural phenomena. We cannot afford to assume that teaching/learning situations in the social studies can be productively studied apart from broader considerations.

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[12] L. H. Ehman, "An Analysis of the Relationships of Selected Educational Variables with the Political Socialization of High School Students," American Educational Research Journal, 6 (November 1969), pp. 559-580.

Overview of Paradigms III and IV

We now turn to a discussion of the scientific-empirical, problem-centered paradigm and the humanistic-philosophic, problem-centered paradigm, Paradigms III and IV respectively. Before they are considered separately, it will be helpful to see their commonalities and how their shared attributes mark them apart from the previous discipline-centered conceptions.

Paradigms III and IV differ from I and II on the basis that the former two prefer to derive their content from practical problems of man and society, not the organized, discrete, social disciplines. That is, content for the social studies is defined by and selected according to significant value-laden personal and/or social practical problems. The distinguishing characteristic of a practical problem inheres in an effort to determine what ought to be done in a personal or social problem situation which contains multiple and possibly conflicting value positions.

In any event, it is being suggested that the major distinctive characteristic of the discipline-centered wing of social studies reform (Paradigms I and II) is the derivation of content from the social science disciplines; the distinctive characteristic of the problem-centered wing (Paradigms III and IV) is the derivation of content from practical problems. Some observers would contend that this is a false dichotomy because practical problems can be incorporated into a discipline-centered course. This, however, reflects confusion between the means and the ends of social studies education.

The content derivation issue centers on two contrasting conceptions of the _ends_ of social studies education. It is important to make this distinction. While the study of practical problems, viewed as the end of formal instruction, does not exclude the use of the organized research disciplines, it does determine the nature of their use. And holding the disciplines as the most important end of classroom instruction does not preclude the use of practical problems in bringing this about, but it does define their character. It is precisely this sometimes overlooked interplay of means and ends which lies at the heart of much of the confusion in the social studies.

The importance of this distinction with respect to heuristic teaching is highlighted by the fact that the study of practical problems is more of an open-ended affair; that is, the answers (and the means for attaining these answers) are not as readily accessible. Keeping in mind the important differences between Paradigms I and II, the heuristic task of the teacher is considerably different from a discipline-centered approach where the answers are largely descriptive and predetermined. With at least a presumptive case made for the differentiating importance of the content derivation concept, we now turn to a discussion of each of the remaining two paradigms. We will move more freely among the categories used in the preceding analysis.

Paradigm III: Scientific-Empirical, Problem-Centered

The alternative now under consideration is basically a pedagogical effort to bring the world of fact, including values _as facts_, and the methodology of fact to bear on the world of value. In the words of Lawrence Metcalf, one of the leading spokesmen, it is an effort to counter the "amalgam of suppression, indoctrination, distortion, manipulation, prescription, and persuasion," which all too frequently characterizes social studies teaching about normative matters.[13]

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[13] L. E. Metcalf, "Some Guidelines for Changing Social Studies Education," _Social Education_, _27_ (April 1963), p. 198. A more recent statement on this position is found in M. P. Hunt and L. E. Metcalf, _Teaching High School Social Studies_, 2nd ed. (New York: Harper and Row, 1968).

Paradigm III, when compared with the others, is least similar to Paradigm II. Whereas Paradigm II proponents are willing to entertain a variety of ways of seeking knowledge, Paradigm III reflects an exclusive adherence to dispassionate scientific approaches. Moreover, the content for such inquiry is necessarily comprised of practical problems; but for Paradigm II, the selection of content focusing on practical problems is unlikely, although it is a possibility under certain circumstances.

Paradigms I and III are similar in their allegiance to the scientific-empirical style of inquiry. They differ, as noted earlier, on the issue of content derivation. The unique assumption of the present paradigm is that most value-conflicting practical problems can be settled by getting the facts straight, a modern version of the Aristotelian dictum that virtue follows from knowledge. Although dealing with content pervaded by values and commitments, the proponents of Paradigm III do not advocate a social studies based upon an "action" program.[14] The purview of social studies is assumed to end with reflection about the practical problems under consideration.

A prominent part of the content base for Paradigm III comes from the students themselves, their knowledge, values, and habits which have been acquired in former experience. In a very significant sense a knowledge of one's students, their backgrounds, interests, sensitivities, and abilities is as important as a knowledge of social science. The successful heuristic teacher in Paradigm III is as likely to be found at student activities, in their homes, and in the community as he is taking an extension course in social science or attending an institute learning about the most recent approaches in social studies education.

It follows from this conception of content that one of the heuristic teaching tasks of the teacher is the creation of an open, nonthreatening classroom climate so that students will feel free to make contributions which in turn can be used as data for reflective classroom analysis. Such a role calls for great skill, tact, and integrity. The teacher must constantly balance the urge for abrasive in-depth probing against the need to protect the student from unnecessary invasion of privacy and humiliation.

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[14] Metcalf, "Some Guidelines," p. 201.

The authority of the teacher in such a classroom may ultimately depend as much on his character as his skill and knowledge. This is in sharp contrast with the assumption in Paradigm I that the teacher's authority lies in his knowledge of social science disciplines and has no intrinsic relationship to the creation of an open classroom climate.

Just as before, the Paradigm III teacher will confront some role frustration. First, he is violating the expectations of the majority of his colleagues who believe that his proper role is, straight out, to teach the social science disciplines. Also, his interest in value-laden, practical problems places him precariously close to the nerve centers of community controversy. Under fire, his only recourse is to the liberal tradition of rational inquiry. This will endear him to the American Civl Liberties Union, but to few others. In the final analysis, as in Paradigm II, the teacher's ability to function heuristically in the ideal role as outlined by the paradigm depends upon his own credibility and the confidence that others have in him. It takes an extraordinarily skilled individual to convince a group whose values he challenges that it is in their interests to tolerate him.

Paradigm IV: Humanistic-Philosophical, Problem-Centered

This conception is most distinctively humanistic and philosophical. Basically, Paradigm IV represents the unique effort to bring values to bear on the appraisal and resolution of value-laden problems. The particular nature of the inquiry process is determined by humanistic-philosophical conceptions of democratic decision-making. While this may include the scientific method, it rarely, if ever, is considered the only appropriate method for all purposes, and never does the ultimate authority for decision-making reside in science. This is in sharp contrast to the scientific-empirical approach of Paradigm III.

Like Paradigm I (and unlike Paradigms II and III), the present conception does have a major developmental base. The Harvard group is representative. Their position, in regard to the ultimate authority of inquiry, is:

> In dealing with problems of public conflict and controversy, the American nation has both inherited and developed a tradition that government and law should be the outgrowth of public debate. Important to this tradition is the value placed

> on the dignity and worth of each individual and, as a corollary, the value placed on the use of reason and persuasion in revolving disputes among people who define differently human dignity and the conditions that promote it. From our point of view, a major goal of the society is to develop public awareness that these basic values should be respected and applied as standards for making public policy . . . .
>
> We . . . assume that basic social values depend upon a government committed to certain procedural principles. . . . In our present framework . . . we have generally accepted the assumption that the violation of any of the principles is cause for concern.[15]

This grounding of the framework in the democratic ethic includes such procedural concepts as "legitimate persuasion," "due process," "checks and balances," and "federalism." At its heart, the meaning of authority is caught up in the liberal, democratic conception of an open society, a society which promotes the development of capable inquirers who can insure their continued growth by prizing and supporting those societal practices which in turn create and preserve open channels of communication and critical analysis. Human dignity, reason, and action are valued components of this paradigm.

The humanistic-philosophic advocate would hold that value conflicts are never "solved." Democratic, pluralistic societies are in a state of constant tension, hence individuals in those societies are locked in a condition of "permanent inconsistency." Inquiry styles are defined by particular situations at particular times. Because of the unique characteristics of each problem, the appropriate methodology depends on the nature of the problem, a methodology which is most consistent with the democratic ethic in the context of the problem. Some disputes or parts of disputes may indeed yield to scientific analysis; however, most require skills of "working out" as well as "finding out." This "working out" engages the inquirer in interpersonal and personal dimensions of inquiry which involve the "anatomy of legitimate communication and persuasion." Choosing the appropriate methodology is an important, if not the most important, decision to be made by problem-solvers. The humanist-philosopher prefers to stay "loose," mixing methodological flexibility with devotion to the democratic ethic.

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[15] D. W. Oliver and J. P. Shaver, Teaching Public Issues in the High School (Boston: Houghton Mifflin Co., 1966), pp. 81-82.

The issue between Paradigms III and IV can be reduced to the belief, on the one hand, that an untempered insistence on a scientific solution to a problem may lead to a detrimental, unreasonable impasse. But, the scientific-empirical adherents argue, on the other hand, that action untempered by facts is merely an irrational expedient; and too many such decisions eventually add up to a societal deterioration or the destruction of democracy itself. The crux of the matter is whether one takes the tenets of the democratic creed as a guide for decision making, which may mean acting precipitately despite or without the "facts," or whether he takes the tenets of scientific methodology as a guide for decision making, which may mean not acting.

Contrary to the other paradigms, the thrust of humanistic-philosophic inquiry is toward social action. Humanistic-philosophic inquiry reveals its fullest meaning in the character of people and is achieved only in actions of individuals in relationship to other people. While some proponents may believe that the social action ideal is presently unrealistic, none will deny its importance as an ultimate goal of social education.

The heuristic teacher in Paradigm IV must be able to do everything required by the other paradigms and endure the accompanying role tensions. He must be able to perform these activities with his "left hand" in order to give him the time and energy to put his own role together in some comprehensible, defensible way. He must not only be able to perform, he must know what he is doing and why he is doing it, for he will undoubtedly be called upon for justification. This teacher is most vulnerable of all for he has chosen to resist the prevailing professional will in two crucial areas of choice: content derivation and inquiry style. He must be able to justify his decision that practical problems with their normative complexities are the legitimate concern of social studies education. Moreover, he must justify an inquiry approach that does not have overwhelming institutional or societal support. He must develop and defend an inquiry approach which is neither just the scientific method nor one which is indoctrinative. We are describing the talents of an extraordinary individual. Our society has a great need for such individuals; this makes it difficult to recruit and retain them for the social studies classroom.

Summary and Conclusions

By seeking differences of opinion with respect to derivation of social studies content, i.e., academic disciplines, or practical problems, and with respect to inquiry styles, i.e., scientific-empirical or humanistic-philosophical, four major social studies paradigms were identified. Several important consequences for the definition and description of heuristic teaching flow from this differentiation.

Does the most worthy content for a social studies program emerge from predetermined sources such as the organized social science disciplines, or does it stem from open-ended, frequently controversial problems of society? If one answers that it more desirably comes from the former, then it follows that the authority of the social studies teacher is grounded in his knowledge of the disciplines and his willingness to accept their underlying values; if it comes from the latter, the authority of the teacher emerges from his ability to structure the classroom inquiry so that these problems are directly linked to the beliefs, values, and experience which students bring to the inquiry.

An open classroom climate, an important condition of heuristic teaching, is desirable in all four paradigm cases, but is not necessary in one. Paradigm I, the scientific-empirical, discipline-centered approach does not require the teacher to foster an open classroom; in this case, then, the meaning of heuristic teaching can be rather narrowly defined as the ability to motivate students to discover what has already been authoritatively determined as meaningful or true by the project interpreters of the social science disciplines. The meaning of heuristic teaching for the remaining three paradigms is vitally related to the necessary condition of an open classroom climate. Within this binding relationship, however, the specific posture of a heuristic teacher may vary according to the particular need for an open classroom. In the humanistic-philosophic, discipline-centered paradigm (II), the need is to provide an openness with respect to the processes for achieving reliable knowledge; in the scientific-empirical, practical problem-centered paradigm (III), the scientific approach is taken as given but the need for openness comes from the position that the beliefs and values of the students should be viewed as an important source of content. Finally, in the humanistic-philosophic, practical problem-centered paradigm (IV), the need is to provide an openness with respect to both concerns expressed by Paradigms II and III.

The research suggests that the cultural and pedagogical influences bearing on the teaching of social studies mitigate against the development of an open classroom climate. Consequently, advocates of heuristic teaching in the social studies often find themselves in opposition to spokesmen for the conventional and the traditional. The task of a heuristic social studies teacher lies close to social conflict and controversy. It can be expected that the implementation of heuristic teaching in the social studies will be received by the school and the public in ways that will probably be quite different from the reception to heuristic teaching in, let us say, mathematics or science.

The characteristics of teachers, also an important variable in heuristic teaching, take on a richer meaning when viewed in the paradigm context. The heuristic teacher must have command of certain technical skills and instructional strategies to function successfully. These skills and strategies will vary with the paradigm. For example, the Paradigm I teacher, engaging his class in a discovery exercise designed to lead the students to a predetermined social science concept, will ask questions and will expect answers consistent with the goal. We can expect him to be unwilling to accept a "wrong" answer because this act would violate the underlying values of the paradigm and would detract from the goal of learning the concept. On the other hand, the Paradigm III teacher should be more willing to accept a "wrong" answer or an ungrounded opinion because one of his heuristic goals is to create a nonthreatening classroom climate which will encourage students to volunteer their ideas and opinions.

The characteristics of a successful heuristic teacher, however, are more inclusive than a command of technical skills and strategies. He requires large portions of personal characteristics such as intellectual honesty, tolerance, political acumen, humor, courage, and compassion. The importance of these qualities cannot be overlooked because the heuristic teacher will be doing many things which violate expectations, particularly in Paradigms II, III, and IV. In many instances, he will have no recourse but to rely on his own credibility as a buffer against the inevitable criticism; and credibility is the sum total of a man's character. The implication is that the selection of teachers may be as important to the promotion of heuristic teaching in our elementary and secondary schools as is the training of teachers.

This analysis has been limited to the boundary-pushing metaphor and has attempted to conceptualize the social studies reform movement of the past decade. It would be instructive for the meaning of heuristic teaching to visualize a futuristic, boundary-breaking kind of social studies. This might come closer to the realization of the heuristic ideal. It is doubtful whether social studies education can be optimally heuristic in schools as most of them are presently organized and as most of them currently function.

AN EXAMPLE OF HEURISTIC TEACHING:
THE STUDENT-CENTERED ENGLISH CLASSROOM

Joseph E. Strzepek[1] and Herbert M. Kennedy
Stanford University

Heuristic teaching emphasizes student-centered learning; English teaching emphasizes subject or discipline-centered learning. Are there too many impediments to allow a merging of these two minds, to admit the possibility of student-centered English classrooms? During the halcyon days of progressive education, immovable English--the study of grammar, rhetoric, and literary history--retreated a bit before irrepressible forces concerned with the growth of the whole child. An Experience Curriculum in English,[2] published in 1935 by the National Council of Teachers of English, marked the culmination of these forces. It described a program of learning based on the student's personal experiences, not on the fundamentals of English as conceptualized by experts in the field. Modern advocates of student-centered English classes should study this document carefully. From the 1950's to the middle 1960's, new developments in linguistics and literary criticism and Bruner's ideas on the importance of teaching the structure of a subject led to the wholesale adoption of subject-centered English curricula in the schools. Today, however, student-centered approaches are winning the headlines, even if they have not yet won acceptance by the majority of the thousands of teachers of secondary and college English.

The British Unstructured Approach

Four books, all published since 1967, which emphatically state the importance of basing instruction in English on the problems and interests of the student are: John Dixon's Growth Through English (1967),[3] James R.

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[1] Now at the University of Virginia.

[2] W. Wilbur Hatfield, An Experience Curriculum in English (New York: Appleton-Century-Croft, 1935).

[3] John Dixon, Growth Through English (Reading, England: National Association for the Teaching of English, 1967).

Squire and Roger K. Applebee's Teaching English in the United Kingdom (1969),[4] James Moffett's A Student-Centered Language Arts Curriculum, Grades K-13: A Handbook for Teachers (1968),[5] and Neil Postman and Charles Weingartner's Teaching as a Subversive Activity (1969).[6] The authors are all English educators, professionals whose teaching, research, and publication are mainly concerned with the teaching of English and the preparation of teachers of English. In these books they describe learning activities, attitudes toward English, and teaching methods which we would incorporate into a definition of heuristic English teaching.

At the 1966 summer Dartmouth conference, English educators from America became strikingly aware of how subject-centered their teaching was compared to the methods advocated by their British colleagues. In reporting on the conference in Growth Through English, John Dixon of the Bretton Hall College of Education in Wakefield, England, outlines the major theoretical elements of what we are now labelling "the British approach" to the teaching of English. Dixon says that three models of English have developed historically and competed for dominance:

> The first centred on skills: it fitted an era when initial literacy was the prime demand. The second stressed the cultural heritage, the need for civilizing and socially unifying content. The third (and current) model focuses on personal growth: on the need to re-examine the learning processes and the meaning to the individual of what he is doing in English lessons (pp. 1-2).

Dixon faults the skills model for failing to transcend drill and practice techniques, even after universal literacy was achieved. He condemns the heritage model for treating literature as ready-made content to be accepted as given, for ignoring the vital interplay between the worlds of students and writers, for ignoring "the processes involved in such everyday activities as talking and thinking things over, writing a diary or even a letter home" (p. 4).

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[4] James R. Squires and Roger K. Applebee, Teaching English in the United Kingdom (New York: Appleton-Century-Crofts, 1969).

[5] James Moffett, A Student-Centered Language Arts Curriculum K-13: A Handbook for Teachers (Boston: Houghton Mifflin Company, 1968).

[6] Neil Postman and Charles Weingartner, Teaching as a Subversive Activity (New York: Delacarte Press, 1969).

It is the student's own language processes and activities that Dixon places at the core of his model of personal growth. Students use language to recreate, reorder, and share experience: to interact with other people. Like George Leonard in Education and Ecstacy, Dixon feels that the English classroom should be a highly volatile, interactive environment of people and objects. In such an environment, continuous and reciprocal feedback enables students (and teachers, we say) to perceive themselves, to grow into the persons they are and wish to be. Such an environment would foster much informal "talk"--not just formalized discussions or debate--among students, would encourage them to try out new roles in creative and improvised dramatics, would respond supportively to the students' personal writings.

"Language is learned in operation, not by dummy runs" (p. 13) is the theme of Dixon's model of personal growth. Students must be active users of language, doers, not the passive audience to texts or the teacher's demonstrations. They, not the teacher, not the subject, must be the focus of the class. Dixon discusses the interaction between the personal responses of students and literature:

> Literature cannot be "taught" by a direct approach, and . . . the teacher who weighs in with talk or lecture is more likely to kill a personal response then to support and develop it. . . . Pupils--and teachers--need to be taught to trust their own responses (p. 58).

Poems and stories are treated as experiences and are talked about as such. Personal responses are exchanged, narrow views are broadened through continued dialogue among the students and the teacher. Solipsism and impressionism give way to desire to interpret literature as it was intended, to see what is really there. Talk about personal experience returns to talk about the experiences in and of the literature being read. "That's me," a student's cry of recognition and identification with a character or situation in a book has two components, says Dixon:

> Our aim is to move dynamically from the me of personal identification to the that of the poem or object in the poem [or novel, drama, story]. The discipline lies in the attention to the that, and it should be made plain that there is no real dichotomy here, but a natural movement from subject [student's personal response] to the object [the text] and back again (p. 59).

Students are encouraged to act out, to improvise their interpretations dramatically. Student writing also focuses on recording and commenting on personal experiences. What writing about literature they do is appreciative: why I liked it, what it means to me. Composition becomes a means of personal expression and development. Rarely does the teacher correct mistakes in spelling or grammar. Rather, the student is supported, encouraged in his attempts to describe and understand his experience. In particular, a great deal of writing of poetry and fiction is done to foster the imaginative abilities to construct experience.

Dixon faults both examination systems and teachers for demanding that students learn "bodies of knowledge" which are of themselves of questionable value. Such bodies of knowledge get incorporated in packaged syllabi and curricula that minimize the student's personal growth.

In Teaching English in the United Kingdom, the model of personal growth which Dixon develops is described by the team of American observers which visited a cross section of schools in Scotland, England, and Wales in the spring of 1967. The findings are stated in terms of comparison to similar activities observed in American schools, reported in High School English Instruction Today.[7] Some of their most significant findings were:

1. A de-emphasis on teaching formal "subject matter" or "content" in English classes in the United Kingdom as compared with practice in American schools.

2. A greater concern in Britain with student response to

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[7] James R. Squires and Roger K. Applebee, High School English Instruction Today (New York: Appleton-Century-Crofts, 1968).

> literature and a corresponding lessening of concern with the planned study of great works and authors.
>
> 3. A greater emphasis in the United Kingdom on the creative uses of language. . . .
> 5. Comparatively little attention in Britain to formal instruction in rhetoric (content of composition) and in the English language (including grammatical analysis).
> 6. Greater emphasis in British schools on the teaching of speech and oral English.
>
> (pp. 238-242)

These findings hold true up until the 6th form, (equivalent to our last years of high school and first year of college), where work becomes dominated by subject-centered cramming for university entrance exams. Before the 6th form, however, observers saw classes that seemed like "happenings." Little attention was paid to any formalized curricula, even when such documents did exist. Significantly, in Britain students do English, whereas in America they take it. British teachers seem to concentrate on the process of writing, whereas we emphasize the finished paper as a product. Observers saw frequent, spontaneous writing for the purpose of expressing feelings, of developing personal fluency, not "correctness"; they saw frequent individual conferences between students and teachers, reading of each other's papers, and class magazines. Notably, this approach to the teaching of writing produces a positive attitude among British students; they enjoy writing. Most American high school students, however, view writing as a form of drudgery or punishment (always associated with exams and red ink). Moreover, British students write as "correctly," if not more so, as do our students, even though ours have had stiff doses of direct teaching of composition and formal instruction in grammar.

The American observers were continually appalled by the British teachers' unwillingness to impose structure or sense of sequence into work, delighted by the frequent and occasional brilliance of dramatic improvisations of ideas and incidents in poems and stories, and confuted by the apparent success of these nonsubject-centered methods. Their findings should be provocative for American teachers of English.

The significant feature of Dixon's model of personal growth and the findings of the Squire and Applebee study of British classes in English are: The students are the active doers, the learners in the classes. The teacher acts as catalyst and supportive gadfly. He, too, is a learner, a participant in discovery.

Moffett's Curriculum

Many of the ideas, attitudes, and activities described in Dixon in theory and reported by Squire's team of observers in Britain, are incorporated and extended by James Moffett. Moffett's Student-Centered Language Arts Curriculum is a description of a sequence of activities for students which he believes facilitates the natural development of linguistic abilities. The plan, field tested for two years in schools throughout the country, emphasizes the use of highly interactive small groups which minimize the teacher's role and multiply the opportunities for students to be active talkers and writers. The activities for the primary grades are dominated by mime, improvisation, dramatic play, and structured and unstructured small group discussions in which students learn the skills necessary for productive thinking. Moffett offers teachers specific suggestions about size of groups and techniques for teaching discussion skills, and for gradually eliminating himself as the authority figure and leader and becoming a resource person for the class.

Also in the elementary grades, reading skills are developed when the students read the language which they have produced: at first their talk is recorded and transcribed by older students or the teacher, and they learn to see their own words; then they read each other's writing. Reading is particularly student-centered in that students are studying the language which they themselves have produced and not just adult published texts.

The same principle is followed throughout the higher grades with respect to writing. The students begin with personal anecdotes, imaginative stories, and sensory descriptions, and move to abstract essays about ideas for more generalized audiences. Significantly employed is the practice of writing interior monologues, which provides students with opportunities to write narratives, poetry of observation, journals, and diaries in which they are the centers and subjects of their work and in which they try both to create and discover themselves.

Perhaps the most effective way to summarize Moffett's curriculum is to present a selection of his own statements:

> I would like to propose a way of teaching the natives language that requires almost no textbooks or materials except reading selections, and that indeed, offers an alternative to the installation of a prepackaged curriculum. Featuring the learner's own production of language, . . . this curriculum adjusts automatically to the students at hand. (Introduction)
>
> 1. A course in language learning is a course in thinking. A writing assignment, for example, is a thinking assignment. Conceiving and verbalizing must be taken together.
>
> 2. Rendering experiences into words is the real business of school, not linguistic analysis, or literary analysis, or rhetorical analysis, which are proper subjects only for college. . . .
>
> 4. The role of the teacher is to help students expand their cognitive and verbal repertory as far as possible, starting with their initial limits. The goal is for the student to become capable of producing and receiving an increasingly broad range of kinds of discourse, compositional forms, points of view, ways of thinking, styles, vocabulary, and sentence structures.
>
> 5. The sequential pathway to this goal is a growth scale from the personal to the impersonal, from low to high abstraction, from undifferentiated to finely discriminated modes of discourse.
>
> 6. The most effective and best motivated learning process for approaching this goal is trial and error, if the trials are roughly sequenced to provide a cumulative experience, and if, through full feedback, the errors are turned to maximum advantage. This means that, in a general way, the teacher selects the trials--the speaking, reading, and writing assignments--and that he sets in motion classroom processes which allow each student 1) to act verbally and 2) to receive enlightening

> reaction to what he has done. This is an action-response model of learning; the student speaks, writes, or reads, and others (particularly other students) respond to his statement, composition, or interpretation.
>
> 7. The only way, short of tutorial, to provide individual students enough language experience and feedback is to develop small-group interaction into a sensitive learning method. The teacher's role must be to teaching students to teach each other. Thus, he frequently breaks the class into small groups for conversing, acting, reading, and writing, setting the structure of these groups by training them, consulting with them, and relating their activities to whole-class presentations.
>
> (From the section, "Summary of Principles," pp. 11-12)

Significantly, Moffett's first principle is the equation of learning language with learning to think. Moffett, however, does not treat thinking to the extent that Postman and Weingartner do in Teaching As a Subversive Activity. On the assumption that in this day of knowledge proliferation students should learn how to learn, Postman and Weingartner recommend that teachers (a) adopt the inquiry method of instruction; (b) throw out all texts, curriculum guides, and lesson plans; (c) concentrate on "what's worth knowing"; and (d) become students of language, the medium of thought. They also recommend that to prepare teachers to be successful participants in classroom inquiry, they should limit themselves to three declarative sentences and 15 questions per class, that they should be tested on what the students know, and that they be prohibited from asking any questions to which they know the answers.

We present here a selection of their ideas which we feel are particularly related to teaching English in a heuristic context:

> Knowledge is produced in response to questions. . . . Once you have learned how to ask questions--relative and appropriate and substantial questions--you have learned how to learn . . . (p. 23).
>
> Good learners, for the most part, are highly skilled in the language behaviors that comprise what we call "inquiry." . . . they know how to ask meaningful questions; they are persistent in examining their own assumptions; they use definitions and metaphors as instruments for their thinking and are rarely trapped by their own language; they are apt to be cautious and

> in making generalizations, and they engage continually in verifying what they believe; they are careful observers and seem to recognize that language tends to obscure differences and control perceptions (p. 32).
>
> The attitudes of the inquiry teacher are reflected in his behavior. When you see such a teacher in action, you observe the following:
>
> *The teacher rarely tells students what he thinks they ought to know*. . . .
>
> *His basic mode of discourse with students is questioning*. . . .
>
> *Generally, he does not accept a single statement as an answer to a question*.
>
> *He encourages student-student interaction as opposed to student-teacher interaction. And generally he avoids acting as mediator or judge of the quality of the ideas expressed*.
>
> *He rarely summarizes the positions taken by students on the learnings that occur*. He recognizes that the act of summary of "closure" tends to have the affect of ending further thought.
>
> *His lessons develop from the responses of the students and not from a previously determined "logical" structure*.
>
> *Generally, each of his lessons poses a problem for students*.
>
> (pp. 34-36)

From their chapter on "Meaning Making":

> *We do not get our perceptions from the "things" around us*. *Our perceptions come from us*. This does *not* mean that there is nothing outside of our skins. . . . "Reality" is a perception, located somewhere behind the eyes (p. 90).
>
> It seems clear to us that if teachers *acted* as if their students were meaning makers, almost everything about the schooling process would change. For example, most school practices are based on the assumption that the student is fundamentally a *receiver*, that the object ("subject matter") from which the stimulus originates is all important, and that the student has no choice but to see and understand the stimulus as "it" is . . . this assumption is false (p. 92).

Then they quote from Earl Kelley's Education for What is Real:

> Now it comes about that whatever we tell the learner, he will make something that is all his own out of it, and it will be different from what we held so dear and attempted to "transmit." He will build it into his own scheme of things, and relate it uniquely to what he already uniquely holds as experience. Thus he builds a work all his own, and what is really important is what he makes of what we tell him, not what we intended.

To which they add, "In other words, you end up with a "student-centered curriculum" not because it is good for "motivation" but because you don't, in fact, have any other choice" (p. 92).

Fundamental to the inquiry method outlined by Postman and Weingartner is the system of language analysis developed by Alfred Korzybski ("one of the most vigorous crap detectors of our age") and known as general semantics. For:

> Granted that each man's perceptions are unique, we still need to know if someone's statements about the world are "better" than someone else's. We need to have ways of telling the difference between a lunatic and a scientist, of distinguishing all the possibilities in between . . . (p. 104).

The ways of general semantics include clarifying the relationships between language and reality, the word and its verifiable referent, and analyzing the denotation and connotation of words in particular contexts. General semantics is certainly not a new discipline. Books by I. A. Richards and S. I. Hayakawa have championed its principles for the past 30 years. But, according to Postman and Weingartner, Korzybski's impact on education, on the ways teachers teach, has been negligible.

This review of these four very important books should give some indication of the flux of ideas and activities currently being associated with heuristic or student-centered English teaching. Yet it also raises a number of questions, and we turn to some of these questions now.

Obstacles to Heuristic Methods

What are some of the obstacles which make it difficult for English teachers to adopt heuristic methods in the classes? We can cite four very quickly: (a) The requirement that the teacher assign each student a numerical or letter grade. Such impersonal, gross evaluation is hardly an effective form of feedback and it fosters a dependence on the teacher's judgment, rather than the student's; (b) compulsory attendance and required courses where students have no choice of classes or teachers; (c) students who do not want to be, or to know how to be, independent, who would rather be told exactly what to do; and (d) teachers who are compulsive about teaching the subject, who are threatened by the idea of student-initiated learning, who do not know how to ask open-ended questions, or, sadly, teachers who have stopped learning.

There are many signs, however, that these obstacles are surmountable. Some schools are adopting pass/fail or evaluation by written comment for some courses. Hopefully, others will institute systematic opportunities for students to evaluate their own learnings, and also to evaluate their teachers. Many English departments have substituted programs of elective courses for the old English I-IV series. Students are learning to handle responsibility from increased opportunity for independent study, and the student power movement is reducing the number of passive learners who want to be led by the hand. The major question is: Will English teachers themselves, conservative by tradition, develop the skills and attitudes necessary to teach their students to teach themselves? It is not an easy thing for some teachers to relinquish their positional authority for authority based on experience and knowledge, to have the ego strength to allow students to criticize and evaluate their ideas as much as they do their students'.

How can we develop English teachers who can teach heuristically, who will be learners themselves, catalysts, not just information disseminators, who will make the classroom a rich, stimulating physical and mental environment? We have some suggestions. We think beginning English teachers should read widely in the burgeoning field of educational literature dealing with student-centered or heuristic teaching. We recommend the four books we reviewed earlier, plus Herbert Hohl's Thirty-Six Children and The Open Classroom, John Holt's How Children Fail and

How Children Learn, George Leonard's Education and Ecstacy, David Holbrook's English for the Rejected, Carl Rogers' Freedom to Learn, and Sylvia Ashton-Warner's Teacher. Also the works of psychologists Abraham Maslow and Rollo May, iconoclasts Paul Goodman and Edgar Feidenberg, and British educator A. S. Neil. We do not believe these books should be treated as the sources of a new holy dogma of the "New Education." We do think prospective teachers, however, would learn a great deal from reading them, subjecting them to the crap detecting and semantic analysis described by Postman and Weingartner, discussing them with each other and with instructors in educational philosophy and psychology, and particularly with professors of English.

We believe that teacher education programs in English, if they would prepare people to teach heuristically, should be largely selective, that instructors in such programs should be able to model inquiry teaching effectively, that the students should participate in planning and evaluating the activities of their courses, that students should have the opportunity to participate in encounter or training groups in order to be able to help them work effectively in groups. We hope that courses in curriculum and instruction in English would stimulate and encourage creative writing and dramatic improvization, both on the part of the instructor and the prospective teachers, and that the new teachers will continue to act and write with their students when they are entrusted with classes of public school children.

Educating Heuristic Teachers

Such a teacher education program might be based on a questions curriculum. We are confident that the students in such a program could raise many stimulating, crucial questions regarding the process of education. We would raise these questions:

> What does heuristic or student-centered teaching in English mean?
>
> What notion of man is served by such teaching? Of society?
>
> If each student goes his own way, if there are no required courses with teacher-written syllabi and performance cri-

teria which enable students to be evaluated according to some objective standard, how can we do research on the effects of heuristic teaching? Since the ideal outcome is "doing one's own thing," will we resort to the techniques of formalistic literary criticism and look at each student as a unique work with his own inherent norms? To what extent is the student aware of his potential for growth, how successfully is he fulfilling it, enlarging it?

What if we merely listen to the students' own ideas of what they think they are learning? In "The Far Side of Paradigms: Conditions for Knowledge-Making in English Education," Gowin and Strzepek[8] suggest that, "A case history of how one student comes to understand one poem may be a most illuminating piece of research" (p. 13).

Will personal knowledge obviate communication between persons, between generations? What kinds of languages with what determinable referents will evolve?

How can we help students organize their perceptions in economical ways, communicate them to others, relate them to new problems and experiences, expand their potentials as learners?

What worth is the wisdom of accumulated experiences of the disciplines or subjects such as English? Have not men from the past 4000 years of civilization produced some things worth knowing to modern individuals? That will help them be better learners? Are there no universals?

Why read Shakespeare, why write poetry, why make new dictionaries?

What place have computer-assisted instruction and programmed instruction in English classrooms? Should there even be classrooms exclusively devoted to the study of a single "subject" such as English?

What forms will heuristic teaching take at varying levels of instruction? Should elementary children be given less freedom than teenagers?

What will it prove if students elect charismatic but authoritarian teachers? Dull authoritarians who can "lay something on them" that is useful or interesting?

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[8] D. Bob Gowin and Joseph E. Strzepek, "The Far Side of Paradigms: Conditions for Knowledge-Making in English Education," English Record (October 1969).

Attempting to deal with these questions, the staff and students in a teacher education program would necessarily become involved in the inquiry process: asking for definitions, revising these questions into clearer more answerable ones, gathering evidence, questioning assumptions.

We suggest that English teachers trained in such a program might be able to stimulate the development of student-centered English curricula in the schools. Such curricula would be dynamic, constantly growing and changing. They would not be written up in a four-week summer workshop by teachers and paid consultants and then left to collect dust on departmental shelves. Such curricula would consist of the ongoing activities planned and carried out and evaluated by the students and the teachers. They would encourage independent or group projects which would get students out of school buildings and into public libraries, factories, theaters, hospitals, museums, government offices, concert halls, parks, meadows, other towns, and even other countries. Instead of formalized classes, although these should continue to exist as a kind of alternative set of choices, students and teachers might form voluntary learning teams which would schedule their own meetings, with or without faculty supervision, which would invite teachers or other relevant experts to participate in their learning projects.

In any case, such curricula can only succeed when there is trust and good faith among students and teachers. Teachers must believe in the student's ability to learn from his mistakes, must have the forebearance not to protect him from making useful mistakes. The advice of the teacher will often be needed, his expertise and experience may often be requested, and it will be, if the students know that he really believes in their ability to learn. For their part, students must learn to use freedom responsibly, to discipline their energies, curiosities, and talents in ways which enable them to increase their capacities for growth and which, significantly, can help other people increase their capacities also. Building this atmosphere of good faith and trust, which would enable all people to be students and teachers, constant cooperative learners, is both the fundamental process and product, the medium and the message of heuristic or student centered teaching.

We believe that student-centered teaching is particularly integral to the teaching of English. Consider this definition of English, conceived by Professor Alfred H. Grommon and published in the March 1967 issue of College English[9] in an article entitled "What is English?"

> It seems to me that English is the study and the use of language, composition and literature; it includes the consideration of values therein and of the attitude and processes essential to critical thinking and problem solving; it also includes the skills of listening, speaking, reading, and writing and the nourishing of students' imagination and creativeness. (Underlining added.)
>
> . . . It is my conviction that, however narrow or broad the teacher's conception of English may be, he should be continuously aware of his responsibilities and rich opportunities for helping students learn to think effectively; become aware of their own values, of those in what they read and in society, and of conflicts in values; and develop their imaginations through all these experiences (p. 464).

We accept this brilliant and concise conception of English. And we submit that this conception is most likely to come to full fruition in student-centered classrooms of the kinds we have described.

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[9] Alfred H. Grommon, "Once More - What is English," College English (March 1967). The authors inverted the order of these two passages.

PART III: DISCUSSION PAPERS AND POSTSCRIPTS

HEURISTIC TEACHING AS A RESEARCH CONCEPT

Lawrence G. Thomas
Stanford University

The purpose of this essay is to clarify some of the ambiguities in current uses of the term "heuristic" in connection with efforts to improve the quality of teaching and learning. The clarification will not seek to stipulate the proper meaning of "heuristic" but will produce some alternative meanings which should be kept distinct and not interchanged with one another. Clear choices among these alternatives are essential in framing research questions and interpreting research findings if investigations in this area are to be unambiguous and scientifically meaningful.

Heuristic Behavior

Let us begin with the meanings of heuristic behavior, regardless of whether the reference is to the act of teaching or the act of learning. There is considerable agreement among the other essays in this monograph on the general meaning of heuristic behavior, even though the emphases vary. It means "to see phenomena problematically" (Bridgham, p. 29), "a seeking, questing, searching attitude" (Tucker, p. 49). It involves positive emotional commitment in the inquiry (Snow, quoted by Eisner, p. 40), and includes "the flexibility to entertain uncertainty and alternate-solution approaches" (Higgins, p. 21). Even more specifically, it entails "creativity, divergent thinking, autonomy, and intuitive insight" (Tucker, p. 61), as well as "a warranted confidence in one's experimental ability" (Bridgham, p. 32).

So far the emphasis has been on the feelings and attitudes expressed in or necessary to this kind of inquiry, but heuristic behavior also involves distinctive cognitive skills. For example, "problem finding is clearly as important as problem solving" (Tucker, p. 49), and requires "the development of self-initiated and self-directed learning" (Snow, quoted by Eisner, p. 39). Once the problem has been located, further skills are needed to solve it. The field of mathematics provided some of the clearest examples of heuristics, "the methods and rules of discovery and invention" (Polya, quoted by Higgins, p. 12). They include, not just obtaining solutions, but seeking generalizations therefrom (Higgins, p. 15).

If there were any serious lack of consensus among these authors on the complex meaning of heuristic behavior, it would be important to identify the differences at this point and present the conflicting choices for their consideration. But such is not the case. Differences in phrasing and emphasis do not mean disagreement, but reflect largely some distinctive characteristics of the particular subject fields being treated. Granted, a composite definition that all authors could subscribe to has not been achieved, but it is not necessary when the signs of consensus are so clear. Thus, I shall resist the philosopher's impulse to tidy up a term with precise categories of meaning, and go on to matters that will concern all of us.

Heuristic Teaching

When our attention shifts from "heuristic behavior" to "heuristic teaching," the signs of consensus among the authors are much less certain. One source of the diversity is the ambiguous referent of "heuristic" when it is used as an adjective. Does "heuristic teaching" refer to the style of the teaching, the aim of the teaching, or the content of the teaching? Other adjectives applied to teaching seldom give us this much ambiguity. When we speak of problem-solving teaching or inquiry teaching, we usually mean the teaching of problem solving or teaching pupils to conduct inquiry. In this case the adjective refers to the content of the teaching. When we speak of humorous teaching or of indoctrination (indoctrinative teaching), we are most likely to mean the aim of the teaching--to get pupils to laugh or to achieve indoctrinated minds. We may also mean a distinctive style of teaching, but we are not referring to a particular content. When we speak of skillful teaching or prefunctory teaching, we mean the expert style of the teaching act or its dull, mechanical quality. We are not referring to its content (e.g., skillful teaching does not mean teaching of skills) nor to any particular kind of aim.

Heuristic teaching, however, may refer to any of these three meanings. To some it is a method which aims at certain results, as in the quotation cited by Higgins from Butler and Wren (Higgins, p. 16). To others, especially to mathematicians, it is a content (heuristics) to be taught (Higgins, pp. 13, 20). To many it is a distinctive style of teaching. Sometimes this style is described without identifying any anticipated effects on the students. If it is a distinctive quality of the teaching act itself, then one can say that some teaching acts are inherently heuristic, independent of the content being taught and of the student responses actually obtained. This view is logically sound, but it has practical difficulties, which will be taken up shortly. An alternative view of heuristic teaching style is to describe both the way of teaching and the responses of the students in the same heuristic terms, as if the connection between a teaching act and a student response could be established by definition. This produces a logical mess, but judging from the frequency of its occurrence in the other essays, it is a tempting view. It, too, will receive detailed attention below.

Two other meanings of heuristic teaching deserve separate identification before commencing a systematic critique. One is the suggestion, syntactically odd but etymologically sound, that heuristic teaching means the creative exploration of the problems of teaching itself. In this vein one essay states, "Teaching is heuristic when it helps the teacher to address problems arising in or from science teaching" (Bridgham, p. 28, emphasis added). Another suggests, "Teachers who can teach heuristically . . . will be learners themselves [concerning how to] make the classroom a rich, stimulating, physical and mental environment" (Strzepek & Kennedy, p. 84). This conception uses the native sense of "heuristic" (seeking to find out about) and proposes teaching itself as the target. This meaning could be more conventionally expressed as "the heuristic study of teaching."

Another meaning, only hinted at in one of the essays (Bridgham, p. 28) but advocated by Gage, Sears, and Snow in the subsequent symposium, would identify as heuristic any teaching act which helps the learner to behave heuristically. This focuses attention where it properly belongs, on the heuristic behavior of the students, but makes a better case for using the term "heuristic learning" rather than "heuristic teaching." If any teaching method can earn the title of heuristic by being found, under specified conditions, to be related to the production of heuristic behavior in students, a given act of teaching may produce heuristic results in one kind of situation but not in another. In contrast, student learning behavior may be called heuristic more or less regardless of the circumstances. A stable definition of heuristic, then, is more likely to reside in student behaviors than in teaching acts.

Researchable Meanings

What is the significance of each of these meanings of heuristic teaching for empirical investigations of the teaching process? One meaning of heuristic referred to something that could be taught as content, such as methods and rules for solving problems. This meaning could lead to investigations of curriculum construction and curriculum design, but these would be only tangential to studies of the teaching process and only formally related to the qualities of heuristic behavior described above. Even though this is a legitimate meaning of heuristic teaching, it is not one of the meanings most often found in the other essays of this monograph, so I shall not pursue it further here. The problems I see in the uses of the concept heuristic teaching do not lie in this direction.

Another meaning of heuristic referred to the aim or the intention of the teaching. While the aim of a teaching act is undeniably important, it is not a major topic for empirical research. Almost any kind of teaching act can claim the intention, on appropriate occasions, of being heuristic, and the fact that the intention is claimed can be empirically ascertained, but this is trivial grounds for classifying the act as heuristic teaching. Granting that all teaching is purposeful, this would be just a way of classifying the professed purposes of teaching. In fact, a teacher could claim to be seeking heuristic goals in student learning but practice highly didactic, authoritarian methods. Would his professed intention be adequate grounds for classifying this kind of teaching as heuristic? Surely not. Moreover, the really important question would be whether his aim was successfully realized. This question cannot be answered by knowing merely the intention of the teaching.

A third meaning of heuristic teaching referred to the process of exploring how to teach better. As indicated above, this actually means the heuristic study of teaching, where teaching is the object of investigation and heuristic refers to the character of the investigation. I am all for heuristic investigations in any field of endeavor, but our concern in these essays is with some object of investigation that can usefully be designated as heuristic.

The most common use of the phrase heuristic teaching in these essays is to indicate a distinctive teaching style. This choice opens up the most significant opportunities for empirical investigation and presents the main problems in a clear usage of the term. Three possible meanings deserve close examination: (a) that some teaching is inherently heuristic, regardless of the subject matter or the results in student learning; (b) that heuristic teaching and heuristic learning can be defined independently of each other and then a match between them sought empirically; (c) that only the learner's behavior can be inherently heuristic, and the kinds of teaching promoting it are entirely empirical questions. Each of these meanings will be taken up in turn.

Inherently Heuristic Teaching

A possible example of the view that some kinds of teaching are inherently heuristic, without dependence on effects or success, is this suggested definition: "A category of instructional methods which make primary use of one or more problem-solving strategies in mathematics" (Higgins, p. 13). No mention is made of anticipated responses from the students nor even a claim that these teaching methods must accomplish some purpose successfully. Hence, the heuristic quality would appear to be inherent in the methods. I have some doubts, however, that this description refers to style of teaching as much as it does to the content of teaching. Problem-solving strategies could be taught in a variety of styles. It is only the content of the strategies that would remain the same and have a constant character.

Another possible example of an inherently heuristic style might consist of the teacher's being a heuristic model in his own behavior--i.e., teaching by modeling. This has initial appeal, but after some reflection, I have questions. If the teaching style is important because it is a model, then its effectiveness depends on the degree to which it inspires imitation. Would we be willing to designate a teaching style as heuristic when it calls forth imitative responses? At first glance this usage looks strange, because imitative behavior is often considered to be at the opposite pole from heuristic behavior, but let us look further into the meanings of imitation.

One meaning of imitate is to duplicate precisely for entertainment purposes, as when a comedian presents, in voice and gesture, his imitations of well-known persons. If the imitation is done with exaggerations, it is called caricature. Some highly specialized talent is required to do this kind of imitating well, but I believe we can agree that it is not the response desired from teaching as a model. Equally inappropriate is another meaning of the term--the identification of imitation with the substitute, the artificial, the counterfeit.

A more promising meaning of imitate is to hold as an ideal, as in the imitation of a hero or a saint. Under this meaning a teacher's heuristic behavior--his questioning attitude, his habit of suspending judgment, his persistent search for alternatives, his tolerance of uncertainty, ambiguity, and plural answers--could become a model or ideal for his young disciples to follow. The teacher's behavior is inherently heuristic by definition, and it becomes heuristic teaching when others accept it as a model to imitate. Note that this kind of heuristic teaching becomes effectual when the teacher is accepted as a model. It is not judged in the first instance by whether the pupils imitate the teacher precisely, because each child may differ in his interpretation of how his ideal would act in present circumstances. Distinctive and characteristic patterns of pupil behavior, on the average, may merge later. But the identifying clue to this kind of teaching is some acceptance of the teacher as an ideal. This conception of teaching raises some fascinating research questions, both empirical and analytical, which have received scant attention in investigations of teaching:

1. What factors influence various types of children in their selection of a behavior ideal?

2. Do they have clear reasons for their selections, or is it largely a matter of the direct intuition of the heart?

3. Can teachers become behavioral ideals to pupils by trying? Directly or indirectly?

4. Can teachers make greater use of their modeling role? Would this mean a diminution in their telling and quizzing roles?

5. Can teaching by being an ideal be judged as successful or unsuccessful? Can the teacher be considered responsible for the results in pupil behavior?

Still another meaning of imitate is to copy, usually slavishly and without much initial understanding. This is the method by which most children learn table manners, rules of etiquette, the order of numerals, the order of letters in the alphabet. Taking for granted a positive affective tone, it is an effective way to learn law observance, respect for proper authority, and respect for racial and ethnic differences. Desirable as these accomplishments are, they are being achieved in settings which stress copying, conformity, and fixed habits. Are these the kinds of situations which are appropriate to the qualities of heuristic behavior described in the consensus above? Some imitative learning may well be a prerequisite to ventures into creativity and divergent thinking but hardly a constituent thereof. One does not learn divergent thinking by diverging the way the teacher does; one has to learn the habits of divergent thinking by initiating his own innovations and finding reinforcement in their unique consequences.

Several other candidates for an inherently heuristic teaching style could be cited, but each faces comparable difficulties in its application. Some are too general to be useful, such as "maintaining an 'open' classroom climate" (Tucker, Bridgham, Strzepek, & Kennedy). Others are so highly specific that they would be feasible only for particular subject matter in extremely limited situations, such as restricting the teacher "to three declarative sentences and fifteen questions per class" (Strzebek & Kennedy, p. 81). A proposal in the middle ranges recommends that the teacher allow the students "to make mistakes and to work their way out of these mistakes" (Tucker, p. 50). Appealing as this is, it could easily fail to win agreement that it is inherently heuristic. Bridgham and Eisner both show convincingly how inventive methods in one situation can be handled didactically in another. And Bridgham goes on to describe many examples of "nonheuristics," including the nonheuristic use of original heuristics in science. These arguments show that the heuristic quality of a teaching method is highly relative rather than inherent.

This conception of heuristic teaching is logically sound, however, in spite of the difficulties of securing agreement and the practical problems of application. Logically, the nature of heuristic teaching becomes a question of definition. Its effects and successes, no matter what they might be, are empirical matters. Thus, a teaching method defined as inherently heuristic may produce desirable results in student learning in some situations, but it may also produce decidedly unwelcome results in other situations. It seems unlikely that we would be willing to acknowledge certain methods of teaching as inherently heuristic (by definition) when the empirical effects on student behavior can vary from good to bad.

Heuristic Teaching and Learning

The second position to be examined is the proposal that heuristic teaching can be defined as one category of acts, that heuristic student behavior can be defined as another category of acts, and that research can seek out the empirical connections between the two. A good illustration of this conception is provided by the four criteria of heuristic teaching suggested by Higgins. Heuristic teaching:

1. Approaches content through problems.
2. Reflects problem-solving techniques in the logical construction of instructional procedures.
3. Demands the flexibility for uncertainty and alternate approaches.
4. Seeks to maximize student action and participation in the teaching process" (Higgins, p. 26).

The first feature indicates a distinctive way to organize subject matter, and the second a way to organize teaching techniques. These two refer exclusively to teaching style and preparation for its display. The third feature is a demand made of the learners for certain attitudes and expectations. It does not describe how the teacher will attempt to evoke these attitudes, but instead characterizes the kind of student behavior the teacher is demanding. "Demanding" is an ambiguous term here. It probably does not mean "insisting" or "requiring" if the teaching is truly meant to be heuristic in its influence. It may mean "aiming at," but we have already seen that the aim of a teaching act is a poor criterion of heuristic. It most likely means "expecting" in the sense that these attitudes are a kind of heuristic behavior on the part of the students that are expected if the teaching is successful. The same expectation holds for the fourth criterion. Again the term "maximize" is ambiguous and might refer merely to the teacher's aim, but let us assume it refers to the degree of heuristic student behavior achieved so far as the teaching is successful. Thus, both the third and fourth criteria indicate the kinds of heuristic student behavior that are expected or desired.

These four criteria, then, are not a definition of heuristic teaching. The first two identify the kind of teacher behavior desired, and the second two describe the kind of student behavior desired. The empirical question is whether the first two will promote the second two. Hence, we have a complex hypothesis rather than a definition.

It is extremely important to keep definitions distinct from hypotheses. Failure to do so is the root of self-fulfilling prophesies. The history of education is crowded with cases of definitions that conceal hypotheses. For instance, consider this faulty syllogism: The purpose of the liberal arts is to liberate the mind. The intellectual subjects constitute the liberal arts. Therefore, their study will liberate the mind. In this case a person who has studied the liberal arts successfully has a liberated mind by definition, not by empirical test. If there is any doubt about a particular student, then there must be something wrong with him (not with the liberal arts), some moral defect, some incorrigible uneducability.

Juxtaposing a selective definition of teacher behavior with a particular definition of student behavior, and then calling the whole thing heuristic teaching by definition, is running the same risk. On the one hand, there is a temptation not to rest the relationship because the only question is one of definition--i.e., that is what we choose to mean by heuristic teaching. On the other hand, if we do check the relationship empirically and get negative results, we may be tempted to evade in any one of three ways: (a) there's something wrong with this particular teacher; (b) there's something wrong with the these students; or (c) we haven't yet found the true definition of heuristic teaching.

The next difficulty I find with this conception of heuristic teaching is the ambiguity of applying the same term to two different sets of behavior, that of the teacher and that of the students. The various efforts and actions that go into the endeavor to teach some material in a creative way are distinctly different from the various efforts and actions involved in trying to learn that material through inventive inquiry. They undoubtedly overlap at several points, but in the main the purposes and functions of these two sets of acts make them far more complementary than identical. Clarity is not served by using the same term to identify both. The temptation to do so may be a function of the desire to affirm a necessary relationship between the two by definition.

A third difficulty with this conception is the constricting effect of linking two kinds of heuristic behavior prematurely. The problem here is with the richness of the hypotheses to be tested empirically. If only certain kinds of teaching acts are stipulated as heuristic, only these will be tested in relation to the occurrence of heuristic student responses, whereas the fact may be that a great variety of teaching acts, under specified circumstances and with specified personnel, actually promote heuristic responses. An equal danger is that teacher acts designated as heuristic will be tested only in terms of their efficacy in evoking certain student responses, defined as heuristic, instead of for the full range of their impact on student behavior. These dangers of premature constriction exist to some extent in all programs of research but they are exacerbated when the central problem is getting two prescriptive definitions of behavior to match up empirically.

My last objection to this conception is the ease with which it can be manipulated to empty "heuristic teaching" of any specific meaning except "successful teaching." My colleagues may not intend to do this, but when they are claiming to focus on teaching style for the meaning of heuristic, they are usually stressing the student behaviors (outcomes) desired. For instance, Snow says, "Heuristic teaching refers to styles of teaching which emphasize the development of self-initiated and self-directed pupil learning; which stress the pupils' discovering rather than absorbing knowledge; which pleases the student in the role of inquirer . . . " (quoted by Eisner, p. 39). All of these phrases refer to the kinds of student behavior sought, not to what the teacher does to elicit them.

Let's look at the logic of this position. The kind of learning actions taken by the pupils under the supervision of a teacher indicates whether or not his teaching is heuristic. It follows that heuristic teaching cannot be identified and analyzed independently of the actual responses of the learners. A teacher may intend to teach heuristically but does not succeed in doing so unless heuristic learning activities occur. In short, this kind of teaching is transactional with a kind of learning. There is no teaching of this kind without learning. Therefore, heuristic teaching is an achievement or success verb (like winning, curing, arriving), not a task verb (like running, hunting, eating).

Followers of this logic would appear to be committed to these significant conclusions:

1. The study of heuristic teaching cannot be conducted independently of effects on pupils.

2. We can agree on what pupil responses are heuristic, but we don't know what heuristic teaching acts are. We have to find these out.

3. Any teaching act which succeeds, at any time and under any condition, in promoting heuristic pupil behavior is by that fact heuristic. In the light of the pupil behavior desired, heuristic teaching is simply successful teaching.

Promoting Heuristic Learning

These conclusions lead me directly into a third conception of heuristic teaching--that only the learner's behavior can be inherently heuristic, and that the kinds of teaching promoting it are entirely empirical questions.[1] In this view there can be no stipulative definition of certain teaching styles that we prefer to call heuristic. The definition will be derived exclusively from the empirical evidence of what works. The kinds of teaching acts that prove to have a high probability of promoting heuristic student behavior might then be designated as heuristic, but the warrant for this claim would be evidential instead of definitional. Heuristic student behavior would be something we know by definition, while heuristic teaching styles would be something to discover.

This position clearly rejects identifying heuristic teaching with the professed aims of instruction or with a pre-set logic of instruction or with a distinctive style considered apart from its consequences. In particular, it opposes such a definition as this: "What we should seek in a definition of heuristic teaching is a relating of the logic of the teaching sequence to the logical patterns of problem solving" (Higgins, p. 17)--unless the intention is to identify heuristic with the content being taught. It also denies a preference for heuristic teaching to refer to styles of teaching, independently of their effects, but with hopes concerning their effects, or intentions concerning the effects.

In view of these different and confusing meanings attached to the term "heuristic teaching," I have some doubts that it is a useful term to retain, even if its meaning is confined to the results of empirical investigations--that is, to the methods and styles of instruction that have a high probability of promoting heuristic behavior among students. If teaching and learning are reciprocal and functionally inextricable, as I believe they are, perhaps we should abandon the terms "heuristic teaching" and "heuristic learning" and call the whole package "heuristic education."

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[1] While the evidence must be empirical, I don't want to suggest that it will automatically present itself. The search for appropriate evidence can be greatly aided, even directed, by clarified conceptions of teaching and learning, and by a coherent theory of instruction.

Problems for Research

If this analysis has clarified some significant differences among the several referents to which the term "heuristic" is frequently and confusingly applied, it is appropriate to conclude with some positive proposals for utilizing the truly heuristic thinking in the other essays for advancing research in this area. To get a broad and common platform from which to launch particular investigations, I would like to see each essay make clear distinctions among the following:

1. Descriptions of the desired qualities to be included in a comprehensive conception of heuristic behavior (these are the aims of ends-in-view).
2. Techniques for identifying these qualities (i.e., establishing that they actually do occur in pupil behavior).
3. Techniques for quantifying their occurrences (to measure degrees of success in the teaching).
4. The means (expressed as hypotheses) that look promising for promoting these qualities.

Many promising means (or methods of teaching) have been cited in these essays, although a number of good ones have been treated like self-fulfilling prophecies or as if they were effective by definition. The fact is, however, that in virtually every case we still need dependable empirical evidence concerning when, how, and if they are effective in promoting heuristic thinking and acting on the part of learners. I would suggest classifying these hypotheses under three headings. One is the general setting in which teaching and inquiry is to take place. We know too little about the possible contributions of various environments to the stimulation of heuristic behavior. Another is the character of the rapport between teacher and students, as well as the rapport among students. Whether this is regarded as a part of teaching or as a precondition of effective teaching, it is sufficiently important to deserve the emphasis of separate listing. Included under this heading are the social qualities of the teacher's personality. Third is the acts and activities initiated by the teacher himself. These are the teaching techniques that usually receive the most attention when the influences on heuristic behavior are under investigation.

To show the relevance of these three categories to the thinking of my colleagues, I have culled several illustrations under each heading from their essays. Some of these illustrations were originally stated as alleged forms of heuristic teaching, but they are repeated here as empirical hypotheses to be tested in the search for influences that actually promote heuristic learning.

The setting:

1. An array of possible projects for individual selection (Eisner).
2. The practical problems of man and society (Tucker).
3. Science laboratories without superrefined equipment (Bridgham).
4. Getting students out of school buildings and into public libraries, factories, theaters, hospitals, government offices, parks, meadows, etc. (Strzepek & Kennedy).

The rapport:

1. Maintaining an "open" classroom climate (Bridgham, Strzepek & Kennedy, Tucker).
2. Students and teachers must be perplexed and must care about their perplexity (Bridgham).
3. Opportunities for students to devise or modify techniques in the laboratory (Bridgham).
4. Reduction in the role of the teacher as a director of classroom activity and discussion (Tucker).
5. Allowing students to make mistakes and to work their way out of these mistakes (Tucker).
6. Declining to impose structure or a sense of sequence into student work (Strzepek & Kennedy).
7. Adopting pass/fail grading and encouraging student evaluations of their own work (Strzepek & Kennedy).

Teaching techniques:

1. Using the students' own language processes and activities (Strzepek & Kennedy).
2. Leading students from the personal to the impersonal, from low to high abstraction (Strzepek & Kennedy).
3. Instead of insisting on the right definition, lead the students to explore the consequences of their own definitions (Higgins).
4. Increase the input of ideas fed into the problem situation by making great use of group processes (Higgins).
5. Encouraging social action as a part and a product of inquiry (Tucker).
6. Encouraging active doubt of all hypotheses until they are fully justified by evidence (Bridgham).

HEURISTIC TEACHING AS PROSTHESIS

Richard E. Snow
Stanford University

A precise definition of "heuristic teaching" is not yet in hand, and perhaps precision is not desirable at this point. It would require our accepting narrow distinctions that easily become too binding and exclusive, given the present state of knowledge in research on teaching. We need terminology that reflects our best guesses and hopes, while remaining flexible enough to incorporate new research findings and to change significantly as a result of them. Choosing the term "heuristic teaching" has itself served more general heuristic purposes in promoting thought about the nature of teaching. Witness the produce of this symposium! So, in its broadest sense, "heuristic teaching" may simply be a device for generating ideas about what makes up "good" teaching. While this tack avoids the definitional issue altogether, it risks losing something of value if theoretically useful definitions can be created. Attempts at more precise definitions are worthwhile, but some difficult problems need resolution first.

Some Definitional Problems

Heuristic teaching is most often taken as a fancy name for discovery or inquiry methods. "Heuristic" does come from the Greek "to discover," though I am told that the term "heuristic teaching" was apparently invented by J. M. D. Meiklejohn of the University of St. Andrews, Scotland, in the 1880s and popularized by H. E. Armstrong.[1] The term also has a long history in German educational literature, where a heuristische lehrform is an instructional method aimed at producing discovery by the learner himself.[2] The association is appropriate, up to a point, but the two terms should not be taken as synonymous, expecially when used to describe psychological processes in teaching or learning. The term "discovery" is itself so loosely and variably defined in education that its use gives only an illusion of progress toward definition.[3] While a discovery is itself an end, a heuristic is only a means to gaining some end. Usually, the end is a problem solution where there are alternative means of approaching the solution, none of which assure success. Heuristic teaching suggests the attempt of some means by a teacher designed to help a learner reach some end, with clear implication that the situation involves a problem for the learner and uncertainty of success for the teacher. In this view, much that would be called discovery method is not heuristic teaching, since the discovery often consists only of artificial and predictable learner inductions of rules or problem solutions imposed and concealed by a teacher. One can speak of a process of learning by discovery in which heuristics are used, but this hardly encompasses all that is meant by heuristic teaching.

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[1] Personal communication, G. W. Parkyn, August 24, 1970. See also H. E. Armstrong, "The Heuristic Method of Teaching, or the Art of Making Children Discover Things for Themselves," Board of Education, England, Special Reports on Educational Subjects, Vol. II (1898), reprinted in H. E. Armstrong, The Teaching of Scientific Method and Other Papers on Education (London: Macmillan, 1903), pp. 235-299.

[2] Personal communication, F. K. Kiewiet, July 16, 1970.

The notion that heuristic implies unpredictability of outcome leads to another aspect of definition, based on the distinction between heuristic and algorithmic processes in mathematical problem solving. The end of an algorithmic process is perfectly predictable; its application leads with certain steps to prescribed and planned consequences. The outcome of a heuristic process is not predictable in advance; its application represents at best a hope that the problem will be clarified, simplified, or altered thereby so that possible solutions are somehow nearer or more apparent. In this sense, a teacher and learner might engage together in activities aimed at solution of a problem faced by one or both. But apparently the activities are not heuristic unless they do result in problem solution, or at least in bringing a solution nearer. If the outcome is unpredictable, then the process can be judged heuristic only in hindsight, perhaps long after the fact. This is not a theoretically useful construction for research on heuristic teaching.

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[3] L. S. Shulman and E. R. Keislar, Learning by Discovery: A Critical Appraisal (Chicago: Rand McNally, 1966).

The idea that heuristic teaching might also involve discovery by the teacher is somewhat novel, though there is no reason why it should routinely be assumed that the teacher always knows what is needed in any situation. There have actually been few scientific discoveries made during the act of teaching. Among these are: Oersted's discovery of electromagnetic fields during a classroom demonstration in 1820, Meyer's 1882 discovery of thiaphene following a lecture-demonstration that "failed," and Planck's reputed conception of the quantum theory of light during a lecture.[4] These were all unpredictable occurrences. To make such events in some way definitional would make heuristic teaching appear like planning for unplanned-for consequences--a seeming impossibility. At least, however, a definition of heuristic teaching will need to include the capitalization of serendipity when it occurs.

Thus, heuristic teaching cannot be defined adequately in terms of learning by discovery, or successful problem solution, or unpredictability of outcome, or the capitalization of serendipity, though all may be considered aspects of a definition. It also seems misleading to define heuristic teaching using any of the apparently simple contrasts like inquiring vs. didactic, inductive vs. deductive, or hypothetical vs. expository. As McDonald indicated in the Center's Second Annual Report (p. 191), "Teaching in the heuristic mode represents no one style of teaching behavior or activity." It must be regarded more as a label for a constellation of roles, styles, and strategies with indistinct boundaries, rather than any particular style or strategy always distinguishable from others. Its main distinctive feature might well be adaptiveness and inventiveness in trying alternative strategies to fit the particular needs of individual learners at specific times, rather than adherence to any one strategy across learners or situations. What works with one learner in one situation will not necessarily work with another learner in the same situation or with either learner in a new situation. The important point may be that heuristic teaching continues adapting and trying alternatives until the learner solves the problem and is satisfied with the solution.

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[4] I am indebted to Robert Bridgham for suggesting the Planck and Meyer examples. See also L. and M. Fieser, Basic Organic Chemistry (New York: Heath, 1959).

The general emphasis on adaptation can be found implicitly or explicitly, I think, in all of the papers in this volume. But adaptation is a second-order concept. One cannot decide whether or not an act is adaptive by looking at that one act alone. A sequence of teaching behavior is needed to display adaptation. And adaptive teaching does not depend on learner success for its definition. Because of the unpredictability of outcome, the teacher is ready to try a new approach if the first fails. Finally, adaptiveness is what is required to take advantage of serendipity.

Perhaps heuristic teaching can only be defined as "second-order" behavior. Much previous Center research has identified specific teaching skills at the level of individual acts. The resource papers gathered in this symposium also include many detailed suggestions and distinctions at what I would call the first order, or individual act or skill level. Rather than attempting to deal with the many ideas at this level, I will try to identify three second-order themes that seem to summarize much of the more detailed thinking. Hopefully, these themes will suggest the main commonalities I see among the resources papers and also show how adaptation to learner needs might be represented as second-order heuristic teaching skills.

Some Heuristic Teaching Skills

In identifying these second-order teaching skills, it may be helpful to use a kind of heuristic I call "the teacher as . . . " devide. By creating an analogy between some aspect of teaching and other known things, concepts, or roles, it is possible to elaborate our understanding of teaching by playing out the analogy's implications. Such analogies are not meant to be closely reasoned or binding in detail, but merely to serve suggestive, hypothesis-generating purposes. For example, one might consider "The teacher as a Bayesian sheepdog." The resulting image is of a barking Collie propelling his bulging flock along a well-worn path by successive statistical estimation and adjustment of the flock's average direction, while racing to keep diverging individuals contained within the group. Such an image sums up many features of classroom teaching as it may be observed in schools today. One might say that our emphasis on heuristic teaching aims to make this as false an analogy as possible.

The teacher as a Whole Earth Catalog: As indicated in the original Whole Earth Catalog publication[5] " . . . a realm of intimate, personal power is developing--power of the individual to conduct his own education, find his own inspiration, shape his own environment, and share his adventure with whoever is interested. Tools that aid this process are sought and promoted by the Whole Earth Catalog." Heuristic teachers may function as such a catalog. They develop a resource collection of interesting facts, problems, activities, observations, experiences, anomalies, analogies, paradoxes, puzzles, etc. They conduct active searches of its contents to serve as gadfly or catalyst in interaction with learners, continually comparing catalog contents with the diagnosed needs, interests, motivations, and readiness of individual learners. Far from being the museum of old heuristic moves mentioned by Bridgham, the collection is continually updated by dropping and adding items according to changing interests and changing times. When learners express interest in particular problems, the teacher-catalog is a ready resource for helpful ideas. When learners do not, it is a ready resource for curiosity arousal. In general terms, this is the problem-finding function of heuristic teaching.

The teacher as a General Problem Solver: Following the problem-finding function of the catalog, a teacher must be a model inquirer and problem solver in his own right, and a transparent one at that. Newell and Simon[6] once created a computer program called the General Problem Solver that was a simulation of human cognitive processes in problem solving. It contained subroutines designed to do all the things that human problem solvers do, including making the same kinds of errors humans usually make. It analyzed problems into parts, asked itself questions, tried heuristic procedures, etc. The contents of the program could be read out for the experimenters to examine the details of the problem-solving processes at any point during the course of a problem.

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[5] Portola Institute, Whole Earth Catalog (Menlo Park, Calif.: Portola Institute, Inc., 1969).

[6] A. Newell and H. A. Simon, "GPS, A Program that Simulates Human Thought." In H. Billing (ED.), Lernende Automaten (Munich: Oldenbourg, 1961). Reprinted in E. A. Feigenbaum & J. Feldman (Eds.), Computers and Thought (New York: McGraw-Hill, 1963), pp. 279-293).

Based on this idea, we can envision a human teacher as an expert problem solver, containing lists of problem-solving strategies, heuristic devices and approaches, questions one should ask oneself, "looking back" routines that seek generalizations, etc. Such a teacher is not only expert but also sensitive to all the errors human problem solvers are prone to make. Most important, the teacher-problem-solver is like an open book (or rather an open computer program). At any point in the problem-solving process, the teacher can read out the details and present state of internal cognitive events for examination and discussion by learners. The teacher is a living, breathing demonstration lesson or model of effective problem solving.

The teacher as a critic: The fields of art, music, literature, and drama have critics--people who review new works, offering evaluative views, and generally interpret developments for people at large. The critic's function is important to the public and also to the artists themselves, providing feedback from individuals more knowledgeable in the field than the average person. If it is good criticism, the feedback offers detailed interpretation and formative evaluation, not merely summary judgment about correctness or worth.

It is suggested that the heuristic teacher is also a critic, concerned with the provision of detailed formative feedback to the learner, the interpretation of the learner to others (parents, other learners, etc.), and with the interpretation of events in the world to the learner. In critiquing the products of independent study, for example, the teacher's consultation, with questions, observations, and subtle cues designed to open the learner's perception or suggest a new way around a problem at hand, may be the most important source of feedback a learner ever receives. It provides information for improvement but, more significantly, develops in the learner the same critical skills for later self-evaluation. The teacher is an observer-interpreter-processor--and perhaps philosopher--about problems in the larger world. Through this function the learner gains attitudes of thoughtful criticism and an increased variety of viewpoints on the world.

A Model of Heuristic Adaptation

A consideration of the three heuristic teaching skills described above, together with the many more specific skills studied so far in Center research, suggests that a model of heuristic adaptation may be found in the concept of prosthesis, i.e., of using prosthetic devices, like artificial limbs and organs, to compensate for specific deficiencies in a learner. Characteristics of instructional treatments, and of teaching generally, can be regarded as prosthetic devices. Skilled teaching then is seen as doing for the learner what he cannot yet do for himself. Heuristic, adaptive teaching further implies both a process of diagnosing learner deficiencies to define specific prosthetic devices and of modeling the devices for eventual learner acquisition to overcome the deficiencies. The teacher acts as a Whole Earth Catalog, a General Problem Solver, and a critic because the learner cannot yet act in these ways in problem situations for himself. By so acting, the teacher also models these skills and the learner eventually acquires them. Teachers thus ask penetrating questions and learners learn self-questioning. Teachers are effective listeners, planners, explainers, and reinforcers; learners gain these proficiencies, too.

This compensatory model of heuristic adaptation leads to a conception of teaching acts as external representations of particular learner needs. Teachers adapt their behavior to complement the strengths and weaknesses of individual learners, supplanting the need for particular learning abilities wherever necessary. And one might generalize still further to imagine the historical evolution of teaching as the gradual institutionalization of externalized learning abilities!

The present discussion is not the place for intensive examination of these ideas. The three general heuristic skills and the rough conception of heuristic teaching as prosthesis suffice to summarize the main themes I perceived in these symposium papers and my reflection upon them. The task of testing the value of such ideas for further theory and research remains.

HEURISTIC TEACHING AND TEACHER EDUCATION

Robert H. Koff
Stanford University

The "unexplained" variance in learning outcomes, which lingers after the effects of aptitude, prior learning, teaching method, and other instructional variables have been removed, has intrigued researchers for years and continues to do so. The search for the source of this variance has produced hundreds of studies relating differences in pupil achievement and attitude to a variety of motivational, social psychological, and cognitive variables. Although results from these studies have been inconclusive, educators have continued to value and work to develop environments and instructional procedures and materials that seek to increase student competence and power over their own learning processes.

Educators of teachers have for years been concerned with the problem of educating teachers in order that they can increase self-directed and self-initiated student learning. Although the aim has remained highly valued over the years, means to achieve the aim have varied. The challenge and the task for teacher educators is to translate aims and good intentions into programs that achieve desired ends.

The need for such programs has never been greater. The coming decades will require of teachers a degree of inquiry, inventiveness, and adaptation to the needs of individual learners not often observed in today's dominant teaching styles. The teacher's role can no longer be viewed only in terms of dispensing knowledge. Further, human teaching will need to complement the projected use of instructional technology to handle many expository instructional functions. Within this instructional context the interaction of teacher and student becomes central to the instructional act.

The instructional context includes other interactive components that influence teacher and student dialogue. Just as we have long recognized that pupil development is not linear, we must recognize that the real world of learning does not consist of carefully constructed situations that are presented to learners as problems-for-solution. Human teachers and students move through an array of stimulus situations, which are potentially problematic in varying degrees, selectively reacting to some and not to others. Situations that are problematic do not present themselves one at a time in a predetermined order, but rather derive their definition and the order in which they are handled from the cognitive and affective activity of the inquirer.

The Center's program on Heuristic Teaching represents an original and practical foray into a most complex educational arena. The program seeks to translate valued educational aims into an applied program of teaching and learning. The program makes a unique contribution to teacher education because it is at once a means as well as an end.

The program is aimed at developing learning abilities, increasing a learner's feelings of self worth and personal competence as he works with others, and improving his control over his own learning processes. Such abilities and attitudes are developed through the utilization of functionally interdependent and interactive instructional procedures, including human teachers and instructional technology, such as films, computer-assisted instruction, and programmed learning.

Heuristic teaching, as a means, emphasizes "inquiring, inductive hypothesis-generating modes of instruction rather than fact-dispensing, deductive, expository modes."[1] Operationally, the program seeks to define what is functionally unique about human teaching in relation to other components of the instructional system. In addition, the program seeks to develop the capability of teachers and learners to take intelligent action.

Intelligent action is defined by Dewey as a process whereby the individual continually evaluates his experience in view of what his purposes are and what consequences he actually experiences. The development of the ability to take intelligent action implies fostering a growing autonomy in the thinker, thereby reducing dependency and reliance on

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[1] R. E. Snow in the Center's Fifth Annual Report (1970).

"authority." One of the most significant problems teachers and learners must cope with, and which the program on Heuristic Teaching faces directly, is that most current educational practice tends to reinforce dependency on teachers or other "authorities."

To develop heuristic teaching competence, teachers need skills that will allow them to monitor their own behavior continuously and test their aims and teaching practices against the reality of the learning situation, their own aptitudes, and learner needs. Thus the program on Heuristic Teaching is founded on the principle that heuristic teaching is itself a continuing process of inquiry rather than a single kind of teaching act that takes place in a defined time frame with particular learners.

The papers presented in this report discuss the meaning of heuristic teaching in relation to particular disciplines. Discussion is focused on aims and the teaching procedures that hopefully will help achieve these aims and the relation of aims and teaching procedures to specific content. One conclusion of interest to teacher educators suggested by the papers is that teachers and learners should always be aware that they are faced with two major tasks integral to heuristic teaching: first, the task of solving whatever problem has been presented by the subject matter, and second, generating or facilitating inquiry processes appropriate to problem solving. It is this latter task to which the remainder of our discussion is devoted, because inquiry processes are themselves means and ends.

Inquiry processes are means in that they determine the methods that will be used to arrive at solutions to problems. Inquiry processes are also ends, in that they represent a series of propositions about the ways in which problems are sensed, defined, and perhaps ultimately related to a particular discipline. Inquiry processes are, in short, isomorphic to heuristic teaching procedures.

According to Richard McKeon,[2] who has written widely about the ideas and methods of the social sciences, physical sciences, and humanities there are four basic types of inquiry, logistical, dialectical, operational, and problematic:

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[2] R. McKeon, Lecture notes taken by the author at the University of Chicago from McKeon's course entitled "The Ideas and Methods of the Social Sciences, Physical Sciences, and Humanities."

> Logistical inquiry refers to the analytical classification of concepts which usually results in statements of relationship between parts and wholes.
>
> Dialectical inquiry initiates with a set of propositions which are then carefully defined and tested.
>
> Operational inquiry refers to the necessity to study only those phenomena that are observable or that can be defined in operational terms.
>
> Problematic inquiry originates with a tension within the inquirer that must be "located" and defined in order to prepare to "move" to another inquiry mode.

These four types of inquiry and perhaps others are utilized by scholars in all of the disciplines. Each discipline, however, has an inquiry mode which is, for a variety of reasons, most "popular." Each discipline has its own tradition of scholars which have added to the "authenticity" of the inquiry mode. For example, operational inquiry has been a primary inquiry mode for the field of American psychology since the turn of the century. Psychologists who are identified with this mode are Watson, Thorndike, Hull, Guilford, Wechsler, Skinner, and Anatole Rappaport: The view that intelligence is what intelligence tests measure is an example of a "product" of operational inquiry. More recent developments where operational inquiry has been operative is reflected in the growing "discipline" called behavior modification.

The important connection to be made between heuristic teaching and use of inquiry mode is that each and every discipline utilizes all of the inquiry modes, some being more "popular" than others, to conduct research. Obviously, the type of inquiry mode that an individual employs will significantly influence the way in which a discipline is "conceptualized," problems particular to the discipline are defined or even sensed, and the manner in which data are used to warrant authenticity of problem-solving activity. Therefore it is extremely important that teachers have a working knowledge of these modes and how they apply to the discipline that they teach.

Heuristic teaching requires that a teacher be able to provide students with viable alternatives to solving problems; alternatives must not be limited to those within a particular inquiry mode. The full range of alternatives represented by all of the inquiry modes should be available to the student to experiment with. The teacher must allow students to experiment with alternative modes of inquiry even if they are "unpopular." Furthermore, the teacher should be able to provide the student with "models" from the discipline that are prototypes of the inquiry mode that the student wishes to pursue.

Heuristic teaching specifies that there are multiple paths to knowledge and hence the ability to take intelligent action. Just as there is room in the discipline of psychology for approaches as diverse as those of J. P. Guilford, Sigmund Freud, and Kurt Lewin so must there be alternatives in learning situations for students. The program on heuristic teaching is committed to generating those alternatives. The implications for teacher education are clear. Teachers must learn what their own predisposition to using a particular inquiry mode is and how that mode is functionally related to their area of specialization. In addition, they must learn how all inquiry modes relate to their discipline and how to recognize students who have different inquiry mode preferences. The ability to apply these learnings in an instructional situation will enable the teacher to assist the student to develop his own "style" of inquiry without doing violence to the aims of heuristic teaching or the discipline that is being taught.

The assertion that individuals differ in the inquiry process employed to solve problems and in their aptitudes should not elicit argument or excitement. It is important to recognize, however, that inquiry preference is at first a matter of "taste." In those just beginning to inquire, the "choice" is probably not consciously derived. An identifiable inquiry mode emerges after an individual has done work which results in the production of a "product." Only after productivity is an individual able to look back and begin to analyze what he did and why.

The looking back process is integral to the development of the ability to take intelligent action. A uniquely human function of a teacher is the ability to assist a student in the "looking back" process.

Looking back with the help of a teacher helps the student to speculate about what he would do differently "next time." Looking back allows teacher and student collaboration so that each can examine aims and means and assess what permanent value has emerged from the learning experience and inquiry. Looking back can tell the teacher whether he should have referred the student to a different scholar model or provided a different "mix" of educational resources. Looking back can provide the teacher and the student with information to decide what lessons or experiences should be taken up next.

In closing, it is recognized that there are multiple outcomes from any unit of instruction or any period of interaction with others. One of these outcomes should be student recognition that there are alternative inquiry modes and that each alternative has its own set of aims and means. With this recognition, which can be greatly facilitated by the teacher, the student will increase his ability to take intelligent action. He will come to know his discipline in ways which will allow him to increase his replicative, associative, applicative, and interpretative knowledge of it.[3]

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[3] H. Broudy, B. Smith, and J. Burnett, Democracy and Excellence in American Secondary Education (Chicago: Rand McNally, 1964).

HEURISTIC TEACHING AND THE STRUCTURE OF KNOWLEDGE

D. B. Gowin
Cornell University

A teacher must know many things in the enterprise of teaching that are not necessarily related to his knowledge of the subject matter which he is responsible for as a teacher. It is always appropriate to ask, however, about how a teacher can be responsible (in a teaching act) for subject matter.

If the teacher uses subject matter as a weapon to control the class, as an instrument to beat down questions, as a device to shut off debate and controversy, as a lever to elevate his authority, then we may be fairly certain that subject matter will not conduce to the pupils finding out things on their own. Pupils will use subject matter as an excuse to disrupt the teacher's planned work ("These problems are too hard"--"We don't know this"--"Why should we read this hard stuff?"), as a reason for not asking questions ("I just did what you told me to read"), as an occasion to argue ("How many pages?"--"How long is the paper supposed to be?"), and as a force to undermine the teacher's authority ("My father read this story and didn't understand it either," or "thought it was inappropriate," etc.). The way the teacher uses subject matter will engender the ways pupils regard it as well.

If the teacher sees subject matter differently--as a celebration of human ingenuity over puzzling and problematic events, as something someone has found out on his own, as a response to human trials and frustrations, as a resource to cut away needless effort, as a device to help in finding one's way about the world, and as having places remaining uncertain and unsolved and unknown--then subject matter can be heuristic in the best sense. It is not subject matter or a discipline in itself which determines these uses.

It is the claim of this paper that if teachers can be instructed to ask and find answers to basic questions about subject matter, then the teachers' basis for heuristic teaching will be a grounded one. Put another way, subject matter specialists in teacher education (science, art, etc.) should be able to help teachers ask and answer these structure-of-knowledge questions because the answers will have definite and specific pedagogical value. The specialist in a discipline (e.g., the professor of English) is rarely concerned with knowledge about knowledge; his very expertness in an area keeps him concerned with the basic problems of scholarship and knowledge production in that area. In a different area, the specialist in teacher education is concerned with the translation or reconstruction of the knowledge claims of the discipline for purposes of teaching. And if one is approaching the concept of teaching from the cluster of meanings which surround the term "heuristic," then the teacher education specialist needs a systematic method for analyzing knowledge claims for their heuristic aspects.[1] The remainder of this paper will be in three parts, concerned with three notions and their interrelations: the concept of teaching, the meanings of heuristic, and a method for analysis of knowledge claims.

Teaching

Much philosophical analysis in recent years has been devoted to the explication of the concept of teaching.[2] A basic issue has been the question of the logical and empirical relationships between "teaching" and "learning." The early philosophical arguments attempting to relate teaching closely to learning by saying, "If there is no learning, there is no teaching, just as, if there is no buying, there can be no selling," were based on the underlying assumption that teaching could be improved by studying the effects of teaching upon learning. This line of argument, initially salutory, had the unfortunate later effect of focusing so much upon learning that any concern with *other* ways of viewing the improvement of teaching were excluded. It is clearly possible to improve teaching by a variety of other moves, such as changing the grouping patterns of pupils, team teaching, technological devices, etc. One way, among many, is to help the teacher take a broader and deeper view of his subject matter. With a more complete view the teacher will be able to enter into transactions with pupils at a variety of places, thereby becoming able to individualize instruction and to help pupils find out things on their own in a richer variety of ways.

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[1] D. B. Gowin, "The Structure of Knowledge," *Educational Theory*, *20* (Fall, 1970).

[2] B. Paul Komisar, "Teaching: Act and Enterprise," *Studies in Philosophy and Education*, *VI* (Spring, 1968), pp. 168-93.

The concept of teaching, in my view, refers to the disciplined and deliberate attempt to change the meaning of experience of pupils by the intervention in their lives with subject matter. The moral justification for this intervention is to be found in the human values of knowledge and truth. There are many ways behavior patterns and belief systems of pupils can be changed. Behavior can be shaped by operant conditioning, physical coercion, bodily beating, electric shock. Belief systems can be changed by deceiving, intimidating, indoctrinating, fear inducing, and brainwashing. These ways and others have been used, and effectively, in the history of education and in the name of educating. All are rejected as candidates for referents to the concept of teaching because they undermine the human values of knowledge making and truth seeking, values characteristically found in subject matter.

The concept of teaching refers to the complex triadic relations between teacher, subject matter, and pupil. Each term in the triadic relation helps to modify and give meaning to the other two terms. It is not merely any relation between teacher and subject matter, but that relation of the teacher viewing subject matter as something to teach the pupil with.[3] Also, it is not just any relation between pupil and subject matter, but the relation of the pupil viewing the subject matter as something set forth by the teacher to be learned by the pupil. Thus the pupil must have, at some points at least, the power to ask the teacher to justify the subject matter as something the pupil must learn.

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[3] To teach, in the standard sense, is at some points at least to submit oneself to the understanding and independent judgment of the pupil, to his demand for reasons, to his sense of what constitutes an adequate explanation. To teach someone that such and such is the case is not merely to try to get him to believe it: deception, for example, is not a method or a mode of teaching. Teaching involves further that, if we try to get the student to believe that such and such is the case, we try also to get him to believe it for reasons that, within the limits of his capacity to grasp, are our reasons. Teaching, in this way, requires us to reveal our reasons to the student and, by so doing, to submit them to his evaluation and criticism. [Quoted from: Israel Scheffler, The Language of Education, (Springfield, Ill.: Charles C. Thomas, 1960), pp. 57-58.]

Finally, teaching is not just any relation between teacher and pupil (e.g., not as pal, counselor, authority figure, enemy, etc.), but that relation that each sees the acts and bearing of the other person in terms of the subject matter under consideration. Thus, teaching is consummated when the meaning of the subject matter which the pupil understands is the meaning the teacher intends the subject matter to have for the pupil. Thus, the educational episodes involving teaching (not all do, of course) are characterized by the deliberate finding, testing, and explication of meanings within subject matter. To teach is to change the pupil's sense of the meaning of his experience through the meditation of the subject matter. The pupil's power to control better his subsequent experience is grounded, not so much in the teacher's authority, as in the pupil's understanding of how subject matter enhances and enlarges his experience. The teacher's responsibility is to see that what the pupil takes from the subject matter does in fact help the pupil in this understanding. The real test lies in the future: in the way the changed belief systems and behavior patterns of the pupil do in fact enhance and enlarge his experience. There is a fuzzy line, or line which is hard to draw precisely, between the end of the teacher's responsibility and the self-directiveness and functional autonomy of the pupil in his now enlarged capacity to control better his subsequent experience.

The Meanings of Heuristic

Heuristic is a term with multiple meanings. As a first distinction note the difference between its use in scientific discourse and philosophic discourse. In scientific work a heuristic is a device for finding out something through procedures other than direct ones. Thus, a construct one invents in the course of inquiry would be heuristic. The terms "gene" and "neutrino" once had that status. The notion that man is like a machine at one time helped biologists to identify parts (organs) and their functions; so, basic analogies and metaphors are heuristic devices in scientific discovery. There is an "as if" quality to these aids. They are not to be taken as direct descriptions of the regularities in phenomena, but rather as ways to give a meaning, one conceivable order, to events, in the hope of finding out more definitely the actual patterns of relations.

In philosophic discourse the term heuristic is applied to arguments or methods or rational demonstration which are persuasive, rather than logically compelling, and which lead a person to find out for himself. Presumably a person uses a heuristic to find out for himself and afterwards puts the arguments in a more carefully considered, logical form. For example, the distinction between necessary and sufficient conditions may be persuasively argued to be like this description of beef stew: If no beef, then no beef stew (beef is a necessary condition for beef stew); if beef stew, then beef (beef stew is sufficient condition for the presence of beef). One may be persuaded that this is a good logical distinction and then go on to put it in a stricter logical form: If not A, then not B; and, if A, then B. It is not logically compelling to substitute the material mode (beef stew) for the formal mode (if A, then B).

Dictionary definitions of "heuristic" include these meanings: (a) serving to indicate or point out; stimulating interest as a means of furthering investigation; (b) (of a teaching method) encouraging the student to discover for himself; and (c) a heuristic method or argument; to find out, discover.

In scientific research the invention of a device which helps to get at obscure phenomena would be heuristic. The device could be something like an instrument (say, a camera) or an intellectual aid, like a construct (e.g., gene, neutrinol). The purpose of the invention would be to further inquiry, to help in finding out new things. It is important to notice that the invention, or device, is only an aid to what one really wants to know about. Put otherwise, a heuristic device is not the same thing as the knowledge claims which the course of scientific inquiry finally establishes. At the end of inquiry, the aid, like a once helpful crutch, may be properly discarded. We may see at once the parallel to teaching;

at the end of an educative episode, the pupil may "discard" the teacher. That is, the teacher was a help to the pupil's finding out something, and the emphasis is not upon the devices the teacher uses, but the knowledge the pupil arrives at. From these different contexts and briefly described uses of the term heuristic, two meanings emerge. First, a heuristic is interestingly indirect. Second, it leads on to better understanding.

These two qualities of heuristic devices have a special meaning for education. One is the quality of indirectness. Some things are better understood by a roundabout route. Indirectness seems as obviously a feature of teaching as of work in science or philosophy. Secondly, there is the important quality of leading on to better understanding. Much teaching is a matter of "from . . . to." From interest to knowledge, from a little understanding to more, from desires to justified and criticized desires, from facts to interpretations, from thoughts to thoughtful actions. Education in its progressive aspects is a matter of moving from interests through educative episodes to facts, generalizations and other knowledge claims, and values. Heuristic devices can help in this progression. Like any aid, however, it must be seen as dispensable. The heuristic must not be allowed to stand for knowledge in its most adequately warranted form any more than the process of understanding can be allowed to stand for the outcome.

Perplexing difficulties arise at this point. A teacher who tries to get pupils to find out things on their own is placed in a paradoxical situation. He is the teacher but he does not teach; he appears to give up his authority and special competence for the sake of having pupils find out something. The pupil likewise is placed in a peculiar situation. He is supposed to find out something he does not know; how will he know when he knows it? If the teacher just tells him he is right when he makes his own discovery, isn't this creating an unwanted dependency on the authority of the teacher? On the other hand, if the pupil is so capable of finding out on his own that there is no need at all for the teacher, then are we merely talking about ways pupils have of learning, and thus not talking about teaching at all?

One way out of these apparent paradoxes is to view teaching and the pupil's development of meanings as episodic, as having a movement through time such that the role the teacher plays at one time is superceded by a substantially different role later.

If we think of educational episodes as having a beginning, middle, and end, then the role of the teacher may appropriately vary. If heuristics are seen as helpful devices in the process of coming to know something, then heuristics in teaching episodes take on different meanings as well. In the beginning the teacher might encourage pupils to guess, estimate, predict, anticipate in an intuitive fashion; formal proofs or established claims come in later, as the conditions for these are better understood by the pupils in the course of their finding out things.

What is it we want pupils to find out? In one aspect we presumably want pupils to find out what the scholars in the special field of study already know. Why can't pupils just read the results as reported in textbooks? There seems to be a conviction that when pupils actually do the work themselves, that is, recreate the knowledge the scholar already has, that the pupils have greater control over their own subsequent experience of finding things out. This conviction should be empirically tested. It is appropriate that we think about how scholars find out things. Discoveries are not self-certifying as to their value; that is, the scholar has a set of standards against which to compare any new reported discovery. These standards are a function of the pattern of inquiry in the field which generates true and useful knowledge. The teacher, then, is interested in getting the pupil to value the process of coming to know the truth in a certain area of human knowledge. Heuristic teaching would encourage the pupil to try on his own to guess, to make mistakes, to see errors. By experimenting and trying and making errors presumably the actual standards of truth will emerge.

There are lots of ways we can get people to find out things on their own. A catalogue inventory of these might be a useful research project. Researchers could just interview a large number of teachers and ask them to describe ways they get pupils to find things out on their own. Some of these will undoubtedly be objectionable. A teacher reports using sarcasm ("Oh yeah; what do you know?!") to shame a pupil into doing some work. Another teacher is just ignorant or incompetent: the pupil decides that if he is ever to know about Cuba he must find it out on his own. Another teacher provides a list of activities and directs the pupils to choose one and then do the work, but the pupil chooses a task for which he already has the requisite knowledge. Another teacher assigns a paper for pupils to compose and just tells them to go to the library and find out the answers there. Another tells pupils to do the problems and check their answers in the back of the book, but the pupils copy the answers instead of doing the problems on their own. And so on. Just getting pupils to find out things on their own is not a sufficient condition to call some schooling activities "heuristic teaching." Suppose a pupil reports, "I found out that the capital of Texas is Houston." Isn't this the place where teaching, as distinguished from merely facilitating learning, comes in? Don't we expect the teacher to correct the mistakes and, in so doing, to get the pupil to see the reasons for the judgment? The teacher helps the pupil to see the appropriate standard to use in judging a false statement in geography.

A different role is played by the teacher toward the end of an educational episode. If teaching is to stimulate the heuristic attitude, it is not enough merely to give sanctions to correct pupil work. The art teacher plays critic to the pupil's completed art work in order to enlarge the pupil's understanding. The art teacher may say, in effect, that this quality is properly displayed in the work, that this other quality could be presented in a better way, that a shortcut technique might be tried next time, and so on. Similarly for the science teacher who permits the pupils to mess around and make mistakes, to invent techniques for getting at phenomena even though the teacher knows of better ways. The science teacher must let the pupils complete the process of finding out by determining what works and what does not. When some things have been found out for sure, the science teacher can still raise questions about how certain the knowledge really is, generate questions about alternative methods, raise appropriate doubts about conclusions, and encourage students to view warranted knowledge as a ground for a more refined try. In this final phase of an episode, the teacher concerned with heuristics can emphasize the contextual nature of knowledge claims (the fact that the meaning of knowledge statements is a function of the context of inquiry which produced them), the limited generalizability of conclusions, and the possibility that different ways of viewing the same phenomena might produce an even more enlightened view.

Analysis of Knowledge Claims

We can be very brief here. The category scheme and examples of its use have been published elsewhere.[4] Suffice it to sketch how the analysis of knowledge claims ties in with heuristic teaching.

Within any field which generates knowledge claims, there exist a large number of knowledge elements. Examples of these elements are: facts, concepts, generalizations, explanations, theories, assumptions, principles, methods, values, and so on. Every subject matter is put together in a characteristic way; that is, the way these various elements are related to each other constitutes the structure of knowledge of that particular field. It is also important to notice that within any field multiple structures are present. The categories of Products, Concepts, Methods, Values, Agent-Audience, and Universe each are composed of a set of questions. These questions can be answered by an appraisal of definitive or characteristic works within any field of study. Using these categories, the structure of knowledge in any field may be identified by its telling questions, key concepts, and conceptual systems; by its reliable and relevant methods of work; by its central and common products; by its internal and external values; by its agent(s) and audience; and by the phenomena the field deals with and the occasions which give rise to the quest for knowledge.

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[4] Gowin, *op. cit.*

D. B. Gowin and J. Strzepek, "The Far Side of Paradigms: Conditions for Knowledge Making in English Education," *The English Record*, *XX* (October 1969), pp. 7-22.

D. B. Gowin and Jason Millman, "Research Methodology--A Point of View," *Review of Educational Research*, *39* (December 1969), pp. 553-60.

Suppose we can imagine an educational setting, taking place over a period of time (an episode), and including as principal actors the teacher and the pupil who are trying to interact with each other through the medium of some selected subject matter. The teacher has a command of the subject matter; that is, mastery of the subject matter is revealed by the teacher's knowledge of its structure (this knowledge can be empirically tested prior to the teaching episode). Suppose we begin with what is often (mistakenly) taken to be the simplest element in the knowledge structure, namely, a fact. The pupil knows a fact or some facts. The teacher ascertains the correctness of this knowledge in some way and now wishes to aid the pupil to move on and discover more. One move for this teacher would be to ask questions about which concepts could be used to refer to the fact. The teacher can be indirect here, leading, probing, questioning, challenging the various concepts the pupils produce until at some point the connection between concepts and facts is validly made. The next step for the heuristic teacher might be to help pupils put the concepts together so as to invent a telling question, or a set of interesting questions. The teacher's greater knowledge of the conceptual structure of the field of study permits him to judge the difference between an important question and one which is mere piffle. The pupils may have to try to answer the question before they will reach this understanding. Hence, if the questions are clear, the next step would concern techniques and methods for answering the questions. Again the teacher can assume the role of a heuristic aid by refusing to tell directly the most appropriate and sophisticated methods of work and to stimulate pupils to try to find workable methods. Next, assuming all the above is grounded and working, open-ended questions about the scene, the phenomena of interest, ways of conceiving of the universe and the like can be entertained. Additional concern with the agent and the audience, with the kinds of values to be found in the area of study, and the like can be explored. Thus, the heuristic teacher helps to build up over the period of the educational episode a whole framework of knowledge, including areas in which knowledge is uncertain or missing.

Clearly a teacher and pupil need not work through an episode always following this path. One can begin anywhere. Progressive teaching begins with well-understood pupil interests and moves through educative episodes into an enlarged experience of tested meaning and knowledge. Pupils may be interested in facts, or concepts, or questions, or ways of working, or any and all of these. A teacher who knows the structure of his subject matter can enter into the teaching act at any of the many places, perhaps a different place for each pupil or small group of pupils. The point would be this: first one place gets firmly grounded, then heuristics is called into play as an aid to lead on to greater understanding. The structure of knowledge analysis gives the teacher greater flexibility in choice of moves. The knowledge about knowledge is a kind of model or heuristic itself. That is, it helps to understand in specific pedagogical moves just what leading on might mean.

It is possible to determine empirically just how any given teacher comprehends the structure of knowledge in his field. Being able to answer the key questions of subject matter is one workable definition of the term "mastery." The empirical researcher who wishes to observe, record, and generalize about heuristics in teaching would need to find ways to keep together the triadic relation between teacher, pupil and subject matter as it develops through episodes. The complexity and difficulty of this task are not to be underestimated any more than their importance is to be denied. This task is a definite one, however, and can be approached along the lines sketched in this paper.

A final caveat: Not everything about the act and enterprise of teaching can be caught up in one idea, such as heuristic teaching or structure of knowledge. In educational research and pedagogical practice, like any other field in which disciplined studies are carried out, there will be multiple knowledge structures. Different concepts, different methods, different specifications of the phenomena of interest are possible and plausible. To be definite is not yet to be definitive.